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PROCEEDINGS

OF THE

ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS.

VOLUME XIV.—1887-88.

EDITED BY

THOMAS COLE,

ASSOC. M. INST. C.E.

(*Secretary of the Association*).

The Association is not as a body responsible for the facts and opinions advanced herein.

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ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS.

LIST OF OFFICERS, 1888–9.

COUNCIL.

President.

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1873–4–5. LEWIS ANGELL, M. Inst. C.E., London.
1875–6. *J. G. LYNDE, M. Inst. C.E., Manchester.
1876–7. JAMES LEMON, M. Inst. C.E., Southampton.
1877–8. F. ASHMEAD, M. Inst. C.E., Borough Engineer, Bristol.
1878–9. G. F. DEACON, M. Inst. C.E., Water Engineer, Liverpool.
1879–80. E. PRITCHARD, M. Inst. C.E., Birmingham and London.
1880–1. *A. MORANT, M. Inst. C.E., Leeds.
1881–2. W. S. TILL, M. Inst. C.E., Borough Engineer, Birmingham.
1882–3. C. JONES, Assoc. M. Inst. C.E., Ealing, W.
1883–4. W. H. WHITE, M. Inst. C.E., Oxford.
1884–5. W. G. LAWS, M. Inst. C.E., Newcastle.
1885–6. R. VAWSER, M. Inst. C.E., Manchester.
1886–7. J. LOBLEY, M. Inst. C.E., Hanley.
1887–8. J. GORDON, M. Inst. C.E., Leicester.

* Deceased.

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H. P. BOULNOIS, M. Inst. C.E., Borough Engineer, Portsmouth.
A. M. FOWLER, M. Inst. C.E., Borough Surveyor, Stockport.
A. W. PARRY, Assoc. M. Inst. C.E., Borough Surveyor, Reading.

Ordinary Members of Council.

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J. CARTWRIGHT, M. Inst. C.E., Borough Surveyor, Bury.
J. H. COX, Assoc. M. Inst. C.E., Borough Surveyor, Bradford.
C. DUNSCOMBE, M.A., M. Inst. C.E., City Engineer, Liverpool.
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E. R. S. ESCOTT, M. Inst. C.E., Borough Surveyor, Halifax.
T. HEWSON, M. Inst. C.E., Borough Engineer, Leeds.
J. B. McCALLUM, M. Inst. C.E., Borough Engineer, Blackburn.
H. U. McKIE, M. Inst. C.E., City Surveyor, Carlisle.
T. DE C. MEADE, Assoc. M. Inst. C.E., Surveyor to the Local Board, Hornsey.
R. READ, Assoc. M. Inst. C.E., City Surveyor, Gloucester.
T. WALKER, Assoc. M. Inst. C.E., Borough Surveyor, Croydon.

District Honorary Secretaries.

Home Counties District.—O. C. ROBSON, Assoc. M. Inst. C.E., Willesden.
Midland Counties District.—A. T. DAVIS, Assoc. M.I.C.E., Stratford-on-Avon.
Yorkshire District.—E. G. MAWBEY, Assoc. M. Inst. C.E., York.
Lancashire and Cheshire District.—S. S. PLATT, Assoc. M. Inst. C.E., Rochdale.
Western District.—JOS. HALL, Assoc. M. Inst. C.E., Torquay.
Northern District.—T. DAWSON, C.E., Banwell.
Eastern Counties District.—E. BUCKHAM, M. Inst. C.E., Ipswich.
Wales.—J. W. M. SMITH, C.E., Wrexham.

General Honorary Secretary.

C. JONES, Assoc. M. Inst. C.E., Ealing, W.

Treasurer.

LEWIS ANGELL, M. Inst. C.E., London.

Secretary.

THOMAS COLE, Assoc. M. Inst. C.E., 6, Westminster Chambers, London, S.W.

HONORARY MEMBERS.

ALPHAND, A.	Inspecteur Général des Ponts et Chaussées, Directeur des Travaux de Paris.
BAZALGETTE, Sir JOSEPH, C.B., M. Inst. C.E.	Metropolitan Board of Works.
CAREY, Major-General C. PHIPPS	Local Government Board, Whitehall.
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HARRISON, J. T., M. Inst. C.E.	Local Government Board, Whitehall.
HAYWOOD, W., M. Inst. C.E.	Guildhall, City of London.
MANSERGH, JAS., M. Inst. C.E.	Westminster.
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SCHUURMAN, J. A.	Directeur des travaux, Amsterdam.
SMITH, S. J., C.E.	Local Government Board, Whitehall.
TAYLOR, ARNOLD	Local Government Board, Whitehall.
TULLOCH, Major H., R.E., Assoc. Inst. C.E.	Local Government Board, Whitehall.
VAN MIERLO, CHAS.	Ingénieur en chef, Directeur de la Ville de Bruxelles.

MEMBERS.

Allen, T. T.	Broad Street, Stratford-on-Avon.
Allies, E. H., Assoc. M. Inst. C.E.	Surveyor to the Local Board, West Derby, Liverpool.
Allison, J., Assoc. M. Inst. C.E.	City Surveyor, Manchester.
Allsopp, John, Assoc. M. Inst. C.E.	Late Surveyor to the Local Board, Worksop, Nottingham.
Andrews, G. R.	Town Hall Chambers, Bournemouth.
ANGELL, L., M. Inst. C.E. *(Past President and Treasurer.)*	Borough Engineer, West Ham.
Armistead, Richard, Assoc. M. Inst. C.E.	Surveyor to the Improvement Commissioners, Bingley, Yorkshire.
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Baker, F., Assoc.M.Inst.C.E.	City Surveyor, Canterbury.
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Barber, J. P.	Surveyor to the Vestry, St. Mary, Islington.
Barley, W. C., Assoc.M.Inst. C.E.	Late Borough Surveyor, Ramsgate.
Barlow, J.	Surveyor to the Local Board, Alton, Hants.
Barret, W. L., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Bognor.
Bateman, J.	Town Surveyor, Pewsey, Wilts.
Batten, W., Assoc. M. Inst. C.E.	150, Lozells Road, Handsworth, near Birmingham.
Baugh, A. C.	Surveyor to the Rural Sanitary Authority, Wrexham.
Beaumont, J.	Late Borough Surveyor, Beverley.
Bellamy, G. D., M. Inst. C.E.	Borough Engineer, Plymouth.
Bennett, T.	Surveyor to the Local Board, Cheshunt.
Bennett, W. B. G., Assoc. M. Inst. C.E.	Borough Surveyor, Southampton.
Berrington, R. E. W., Assoc. M. Inst. C.E.	Borough Engineer, Wolverhampton.
Biddle, G.	L. and N. W. Ry. Estate Department, Lime Street Station, Liverpool.
Blackshaw, W.	Borough Surveyor, Stafford.
Blair, W. N., Assoc. M. Inst. C.E.	Borough Surveyor, Bootle-cum-Linacre.
Bland, D.	Surveyor to the Local Board, Chesterton, Cambridge.
Boulnois, H. P., M. Inst. C.E. (*Vice-President.*)	Borough Engineer, Portsmouth.
Bourne, J.	18, Grove Terrace, Grove Lane, Handsworth, Staffordshire.
Bowen, W.	Borough Surveyor, Stoke-on-Trent.
Bower, Jas., M. Inst. C.E.	Borough Engineer, Gateshead-on-Tyne.
Bressey, J. T.	Surveyor to the Local Board, Wanstead, Essex.
Brierley, R.	Town Surveyor, Newton-in-Makerfield, Lancashire.
Brockbank, W. Hy.	Borough Surveyor, Bolton.
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Broughton, T., Assoc. M. Inst. C.E.	Bolton Abbey, Skipton, Yorkshire.
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Brown, Jos. W.	Borough Engineer, West Hartlepool.
Brumell, G. W.	Surveyor to the Local Board, Finchley.
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Burton, J. H.	Surveyor to the Local Board, Audenshaw, Lancashire.
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Capon, E. R.	Surveyor to the Local Board, Skegness.

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Clavey, E.	Borough Surveyor, Burton-upon-Trent.
Cloutman, W.	Surveyor to the Rural Sanitary Authority of St. George, near Bristol.
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Comber, A.	Borough Surveyor, Kidderminster.
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Cooper, J., Assoc. M. Inst. C.E.	Burgh Engineer, Edinburgh.
Cooper, W. W.	Surveyor to the Local Board, Hinckley.
Coulson, W. L.	Surveyor to the Local Board, Aldershot.
Cousins, E., M. Inst. C.E.	Late Borough Surveyor, Swansea : 9 Bridge Street, Westminster.
Cox, J. H., Assoc. M. Inst. C.E (*Member of Council.*)	Borough Surveyor, Town Hall, Bradford.
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Crimp, W. Santo, Assoc. M. Inst. C.E.	Surveyor to the Local Board, Wimbledon.
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Davies, W. A.	Surveyor to the Local Board, Aston Manor.
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Dawson, C. J.	Surveyor to the Local Board, Barking.
Dawson, T. (*Member of Council.*)	Surveyor to the Local Board, Benwell, near Newcastle-on-Tyne; *Hon. Secretary*, Northern Counties District.
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Dixon, Isaac	Surveyor to the Local Board, Wavertree.
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Duff, R. J.	Borough Surveyor's Office, Doncaster.

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ELLICE-CLARK, E. B., M. Inst. C.E. (*President.*)	County Surveyor for Sussex (West), Connaught Mansions, Westminster, S.W.
Escott, E. R. S., M. Inst. C.E. (*Member of Council.*)	Borough Engineer, Halifax.
Farrar, J., M. Inst. C.E.	12, Market Street, Bury.
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Fiddian, W.	Town Surveyor, Stourbridge.
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Gaskell, P.	Surveyor to the Local Board, Hornsea, near Hull.
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Gledhill, T.	Town Surveyor, Heckmondwike, Yorkshire.
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Goldsworth, W.	Surveyor to the Local Board, Prescot, Lancashire.
Gomoszynski, C. T.	Borough Engineer, Tynemouth.
Goodall, S. A.	Surveyor to the Local Board, Fenton.
Goodyear, H.	Borough Surveyor, Colchester.
GORDON, JOS., M. Inst. C.E. (*Past President.*)	Borough Engineer, Leicester.
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Grieves, R.	Surveyor to the Local Board, Hexham.
Grimley, S. S., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Hendon.
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Hall, Joseph, Assoc. M. Inst. C.E.	Surveyor to the Local Board, Torquay; *Hon. Secretary*, Western Counties District.
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Hall, W.	Surveyor to the Local Board, Great Crosby.
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Harding, J.R., Assoc. Inst. C.E.	Surveyor to the Local Board, Epsom, Surrey.

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Harpur, S., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Merthyr Tydfil, Glamorganshire.
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Heward, T. L.	Surveyor to the Local Boards New Malden and Carshalton.
Hewson, T., M. Inst. C.E. (*Member of Council.*)	Borough Engineer, Leeds.
Heys, Joseph	Surveyor to the Local Board, Hurst Brook, Ashton-under-Lyne.
Higgins, C., Assoc. M. Inst. C.E.	Surveyor to the Parish of Islington.
Higginson, T.	Surveyor to the Local Board, Widnes.
Hiscocks, A. M.	Surveyor to the Parish of St. George the Martyr, Southwark.
Hodge, R.	Late Borough Surveyor, Plymouth.
Hodson, Geo., M. Inst. C.E.	Loughborough.
Holt, A., Assoc. M. Inst. C.E.	Borough Surveyor, Lewes, Sussex.
Hooley, Cosmo C., Assoc. M. Inst. C.E.	Rural Sanitary Authority, Barton-upon-Irwell, Patricroft.
Hooley, E. P., Assoc M. Inst. C.E.	Surveyor to the Rural Sanitary Authority, Maidstone.
Hooper, J. D.	Surveyor to the Local Board, Woodford, Essex.
Horne, W.	Engineer to the Local Board, Worthing.
Horsfield, J. W.	Borough Surveyor, Batley.
Howcroft, James	Surveyor Kirkleatham Local Board, Redcar, Yorkshire.
Hughes, Robt.	Town Surveyor, Rhyl, Flintshire.
Hutchinson, R.	Borough Surveyor, Huntingdon.
Inch, R. H., Assoc. M. Inst. C.E.	Late Town Surveyor, Lowestoft, Suffolk.
Inglis, J. C., M. Inst. C.E. ..	Surveyor to the Local Board, Compton Gifford.
Irving, W. E.	Surveyor to the Municipal Shire of Toowong, near Brisbane, Queensland.
Jeeves, Ed.	Surveyor to the Local Board, Melton Mowbray.
Jenkins, D. M.	Borough Engineer, Neath.
Jennings, G.	Borough Surveyor, Rotherham.
Jerram, G. B., Assoc. M. Inst. C.E.	Late Surveyor to the Local Board, Walthamstow, Essex.
Jones, A. S., Lt.-Col., V.C., Assoc. M. Inst. C.E.	Engineer to Urban Sanitary Authority, Wrexham.
JONES, C., Assoc. M. Inst. C.E. (*Past President and General Hon. Secretary.*)	Surveyor to the Local Board, Ealing, Middlesex.
Jones, I. M., Assoc. M. Inst. C.E.	City Surveyor, Chester; Engineer to the Dee Bridge Commissioners.
Kerridge, Jas.	Surveyor to the Local Board, Walsoken.
Knowles, E.	Late Borough Surveyor, Accrington, Lancashire.
Kirk, Thos.	City Engineer, Brisbane, Queensland.
Lacey, F. W., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Brentford.

Laffan, G. B., Assoc. M. Inst. C.E.	Borough Surveyor, Bridgewater.
Lailey, C. N.	Surveyor to the Local Board, Acton.
Land, Geo.	Surveyor to the Local Board, Norden, near Rochdale.
Latham, E. D., Assoc. M. Inst. C.E.	Borough Surveyor, Middlesbrough, Yorkshire.
LAWS, W. G., M. Inst. C.E. (*Past President.*)	City Engineer, Newcastle-on-Tyne.
Lawson, C. G., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Southgate.
Leete, Wm. H.	Borough Surveyor, Luton, Bedfordshire.
LEMON, J., M. Inst. C.E. (*Past President.*)	Consulting Engineer, Southampton; and 62, Palace Chambers, Westminster.
Livesay, J. G., Assoc. Inst. C.E.	Consulting Engineer to the Local Board, Ventnor.
LOBLEY, J., M. Inst. C.E. (*Past President.*)	Borough Engineer, Hanley, Staffordshire.
Lockwood, P. C., M. Inst. C.E.	Borough Surveyor, Brighton, Sussex.
Lofthouse, J. P.	Town Surveyor, Stroud, Gloucestershire.
Longdin, Thos.	Borough Surveyor, Warrington.
Lovejoy, C. C.	Local Board, Watford, Herts.
Lowe, C. H.	Surveyor to the Vestry, Hampstead.
Lund, J.	Borough Surveyor, Bedford.

MacBrair, R. A., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Lincoln.
MacGregor, D. M.	Town Surveyor, Berwick-on-Tweed.
Mair, H.	Surveyor to the Parish of Hammersmith.
Mallinson, J.	Surveyor to the Local Board, Colne, Lancashire.
Mallinson, T.	Surveyor to the Local Board, Selby.
Mann, Jabez	Surveyor to the Local Board, Sevenoaks.
Marks, H. F., A.M.I.C.E.	Borough Engineer, Dewsbury.
Marks, T. T., Assoc. M. Inst. C.E.	Town Surveyor, Llandudno, Carnarvonshire.
Marsh, R. S.	Surveyor to the Local Board, Cockermouth.
Marshall, P. P.	Borough Engineer, Norwich.
Mathews, G. S.	Surveyor to the Local Board, Dorking.
Maughan, J.	Late Borough Surveyor, Great Grimsby, Lincolnshire.
Mawbey, E. G., Assoc. M. Inst. C.E. (*Member of Council.*)	City Surveyor, York; *Hon. Secretary*, Yorkshire District.
Mawson, Jno.	Local Board, Shaw, near Oldham.
May, F. J. C., Assoc. M. Inst. C.E.	Borough Surveyor, Maidstone.
Mayor, T.	Surveyor to the Local Board, Gorton near Manchester.
McBeath, A. G., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Sale, Cheshire.
McCallum, J. B., Assoc. M. Inst. C.E. (*Member of Council.*)	Borough Engineer, Blackburn.
McKie, H. U., M. Inst. C.E. (*Member of Council.*)	City Engineer, Carlisle.
Meaby, M. C.	Surveyor to the Vestry, St. Luke, Middlesex.
Meade, T. De Courcy, Assoc. M. Inst. C.E. (*Member of Council.*)	Surveyor to the Local Board, Hornsey.
Metcalf, J. W.	Surveyor to the Rural San. Authority, Ashby-de-la-Zouche.
Middlebrook, S.	Surveyor to the Local Board, Walton-on-the-Hill.
Middlemiss, T. W.	Surveyor to the Local Board, Morpeth.

MILES, E. L.	Surveyor to Rural Sanitary Authority, Blaby, Leicestershire.
MITCHELL, J.	Borough Surveyor, Hyde, Manchester.
MOLINEUX, W. F. T.	Town Surveyor, Shifnal, Salop.
MORGAN, W. B.	Borough Surveyor, Weymouth and Melcombe Regis, Dorsetshire.
MORRIS, JNO.	Surveyor to the Local Board, Neston.
MOUNTAIN, A. H.	Surveyor to the Local Board, Swinton (Lancashire)
MYATT, J.	Town Surveyor, Leek.

NEWMAN, F.	Borough Engineer, Ryde, Isle of Wight.
NEWTON, J., M. Inst. C.E.	Carlton Buildings, Manchester; Engineer to the Local Board, Bowdon, Cheshire.
NEWTON, W. J., Assoc. M.I.C.E.	Borough Surveyor, Accrington.
NORRINGTON, J. P.	Surveyor to the Vestry, Fulham.
NORRISH, G. R.	Surveyor to St. Saviours, Southwark.
NUTTALL, T., Assoc. M. Inst. C.E.	Surveyor to the Local Boards, Keasley and Ramsbottom, Lancashire.

PARKER, J., Assoc. M. Inst. C.E.	Surveyor to the Basford Union, Rural Sanitary Authority, Nottingham.
PARKER, J., Assoc. M. Inst. C.E.	City Surveyor, Hereford.
PARKINSON, JAS.	Surveyor to the Local Board, Turton, near Bolton.
PARRY, A. W., Assoc. M. Inst. C.E. (*Vice-President.*)	Borough Surveyor, Reading.
PATTISON, J., jun.	Borough Surveyor, Newcastle-under-Lyme.
PENTY, W. G.	Surveyor to the Rural Sanitary Authority, York.
PETREE, J.	Borough Surveyor, Jarrow.
PICKERING, RICHARD	11, Lowther Street, Whitehaven.
PILDITCH, J. T.	Surveyor to the Parish of Battersea.
PLATT, S. S., Assoc. M. Inst. C.E. (*Member of Council.*)	Borough Surveyor, Rochdale; *Hon. Secretary* Lancashire and Cheshire District.
POLLARD, J., Assoc. M. Inst. C.E.	Late Surveyor to the Local Board, Hendon. 7, Gt. Queen Street, Westminster.
PORTER, R.	Borough Surveyor, Wakefield.
PRICE, JOHN, Assoc. M. Inst. C.E.	Surveyor to the Local Board, Toxteth Park, Liverpool.
PRITCHARD, EDWARD, M. Inst. C.E. (*Past President.*)	37, Waterloo Street, Birmingham, and 2 Storey's Gate, S.W.
PROCTOR, J., M. Inst. C.E.	13, Mawdesley Street, Bolton, Lancashire.
PURNELL, E. J.	City Surveyor, Coventry, Warwickshire.

RADFORD, J. C.	District Surveyor, Putney.
RAMSDEN, A.	Surveyor to the Local Board, Chiswick.
READ, RICHARD, Assoc. M. Inst. C.E. (*Member of Council.*)	City Surveyor, Gloucester.
RICHARDS, R. W.	City Surveyor, Sydney, N.S.W.
RICHARDSON, JAS.	Urban Sanitary Authority, Stamford.
RICHARDSON, H.	Surveyor to the Local Board, Oldbury.
ROBINSON, W. J., Assoc. M. Inst. C.E.	City Surveyor, Londonderry.
ROBSON, O. C., Assoc. M. Inst. C.E. (*Member of Council.*)	Surveyor to the Local Board, Willesden, Middlesex; *Hon. Secretary*, Home Counties District.
ROTHWELL, E.	Late Surveyor to the Local Board, Norden near Rochdale. Tramways Co., Rochdale.
ROUNTHWAITE, R. S.	Borough Engineer, Sunderland.
ROWE, WM.	Tiverton, Devon.
ROYLE, H., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Stretford, Lancashire.

Ruck, F. W.	County Surveyor, Kent, Maidstone.
Rumble, F. J.	Surveyor to the Local Board, New Barnet.
Sadler, G. W.	Surveyor to the Sanitary Authority, Cheltenham.
Savage, Wm. Hy.	Surveyor to the Local Board, East Ham.
Scott, R. S.	Surveyor to the Local Board, Bishop's Stortford.
Sharman, E.	Surveyor to the Local Board, Wellingborough, Northamptonshire.
Sheppard, Geo.	Borough Surveyor, Newark.
Shuttleworth, F. H., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Littleborough, Lancashire.
Siddons, J. M.	Town Surveyor, Oundle.
Silcock, E. J., A. M.Inst.C.E.	Borough Surveyor, King's Lynn.
Smith, G. F.	Surveyor to the Local Board, Milverton, Warwickshire.
Smith, J. W. M. (*Member of Council.*)	Borough Surveyor, Wrexham, Denbighshire, *Hon. Secretary*, Wales District.
Smythe, F.	Surveyor to the Rural Sanitary Authority, Solihull.
Spencer, J. P., A.M.Inst.C.E.	50, Side, Newcastle-on-Tyne.
Spinks, W., Assoc.M.Inst.C.E.	Surveyor to the Local Board, Dukinfield.
Stafford, J. E., Assoc. M. Inst. C.E.	Late Borough Engineer, Burnley.
Stainthorpe, T. W.	Surveyor to the Eston District Local Board, Yorkshire.
Stansfield-Brun, J., Assoc. M. Inst. C.E.	Town Surveyor, Bradford-on-Avon.
Stephens, R. J.	Surveyor to the Local Board, Belgrave.
Stevens, George	Borough Surveyor, Godmanchester.
Stewart, A.	Surveyor to the Rural Sanitary Authority, Maldon.
Stewart, Wm.	Surveyor to the Local Board, Rugby.
Stokoe, J.	Surveyor to the Local Board, Altrincham.
Strachan, G. R., Assoc. M. Inst. C.E.	Surveyor, Chelsea.
Stringfellow, H. W.	City Surveyor, Chichester.
Stuart, J. C.	Surveyor to the Local Board, Smethwick.
Stubbs, Wm., Assoc. M. Inst. C.E.	Borough Surveyor, Over Darwen.
Swarbrick, Joseph, Assoc. M. Inst. C.E.	Surveyor to the Local Board, Withington, near Manchester.
Swindlehurst, J. E., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Rawtenstall.
Sykes, Ed., A.M.I.C.E.	Surveyor to the Local Board, Cheadle, Manchester.
Tanner, W.	County Surveyor, Monmouthshire, Newport.
Taylor, H. A., M. Inst. C.E.	Surveyor to the Local Board, Clevedon, Somerset.
Thomas, John	Surveyor to the Rural Sanitary Authority, Swansea.
Thomas, W.	Surveyor to the Margam Local Board, Porttalbot, S.W.
Thomas, W., Assoc.M.Inst.C.E.	Borough Surveyor, Dover.
Thomas, W. E. C., Assoc. M. Inst. C.E.	Surveyor to the Rural Sanitary Authority, Neath.
Thompson, R.	Surveyor to the Local Board, Waterloo, near Liverpool.
Thorburn, T. C.	Borough Surveyor, Birkenhead.
Thorrold, S. E.	Surveyor to the Local Board, Redditch.
TILL, W. S., M. Inst. C.E. (*Past President.*)	Borough Engineer, Birmingham.
Tomes, C.	Borough Surveyor, Eastbourne.
Trapp, S. C.	88, Mosley Street, Manchester.

Tudor, E. C. B.	Surveyor to the Local Board, Goole, Yorkshire.
Turner, L.	Surveyor to the Rural Sanitary Authority Headington, Oxford.
Valon, W. A. McIntosh, Assoc. M.I.C.E.	Ramsgate Corporation Gas Works Engineer.
VAWSER, R., M. Inst. C.E. (*Past President.*)	17, Cooper Street, Manchester.
Wakelam, H. T., A.M.I.C.E.	Surveyor to the Local Board, Garston.
Walker, T., Assoc. M. Inst. C.E. (*Member of Council.*)	Borough Surveyor, Croydon, Surrey.
Wallis, T. W.	Borough Surveyor, Louth.
Walshaw, J. W.	Borough Surveyor, Peterborough.
Wardle, J. W., Assoc. M. Inst. C.E.	Borough Surveyor, Longton.
Watson, J. D., Assoc. M. Inst. C.E.	Burgh Surveyor, Arbroath, N.B.
Weaver, Wm., Assoc. M. Inst. C.E.	Surveyor to the Vestry, Kensington.
Webster, J. L.	Borough Surveyor, Malton.
Welburn, W.	Borough Surveyor, Middleton near Manchester.
Weston, Geo.	Surveyor to the Vestry, Paddington.
Wheeler, G. R. W., Assoc. M. Inst. C.E.	District Surveyor, Westminster.
Wheeler, W. H., M. Inst. C.E.	Borough Surveyor, Boston, Lincolnshire.
White, A. E.	Borough Engineer, Hull.
WHITE, W. H., M. Inst. C.E. (*Past President.*)	Engineer to the Local Board, Oxford.
Whitlow, Henry	Surveyor to the Local Board, Ulverston.
Wild, G. H.	Surveyor to Local Board, Wuerdle and Wardle, Lancashire.
Wilds, W. H.	Borough Engineer, Hertford.
Wilkinson, J. P., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Newton Heath, near Manchester.
Willcox, J. E., Assoc. M. Inst. C.E.	118, Colmore Row, Birmingham.
Wilson, Geoffrey	Surveyor to the Local Board, Alnwick.
Wilson, J. B.	Court House, Cockermouth.
Wilson, J.	Borough Surveyor, Bacup, Lancashire.
Wilson, William	Surveyor to the District Local Board, Dalton-in-Furness.
Willson, J.	Surveyor to the Local Board, Ashford, Kent.
Window, A.R., Assoc. M. Inst. C.E.	Late Surveyor to the Local Board, Bishop's Stortford, 2, Fairfield Street, Prescot St., Liverpool.
Winship, G., A. M. Inst. C.E.	Borough Surveyor, Abingdon, Berks.
Witts, J. W.	Town Surveyor, Skelton in Cleveland.
Wolstenholme, J.	Borough Surveyor, Blackpool.
Wood, A. R.	Surveyor to the Local Board, Tunstall.
Woodbridge, C. A.	Surveyor to the Local Board, Pinner.
Worswick, R. A.	Surveyor to the Local Board, Saltburn-by-the-Sea.
Worth, J. E., Assoc. M. Inst. C.E.	Engineer to the Local Board, Tottenham.
Wright, J.	Borough Surveyor, Macclesfield, Cheshire.

GRADUATES.

Ball, Geo.	Borough Surveyor's Office, Scarborough.
Barnes, S. W. J.	Local Board Offices, Ealing, W.
Coales, H. G.	Beaconsfield Place, Southall.
Cook, J.	Borough Surveyor's Office, Bury.
Cooper, C. H., A.M.I.C.E.	Surveyor's Office, Wimbledon.
Crow, A.	35, Queen Victoria Street, E.C.
Fenton, W. C.	Borough Surveyor's Office, Sheffield.
Franks, T. W.	Town Hall, West Bromwich.
Glass, S. N.	Town Hall, Hackney, E.
Greatorex, A. D.	Surveyor's Office, Town Hall, Manchester.
Houghton, J.	Surveyor's Office, King's Norton.
Jameson, M. W.	Town Hall, Hackney, E.
Lynam, G. T.	14, Huddersfield Road, Barnsley.
Mellor, T. E. W.	Town Surveyor's Office, Tunbridge Wells.
Nickols, F. J.	Borough Surveyor's Office, Leeds.
Parker, W.	Borough Surveyor's Office, Hereford.
Pickering, J. S.	3, Dugdale Street, Nuneaton.
Pritchard, T.	Town Surveyor's Office, Richmond, Surrey.
Rich, E. W.	Alderwich House, Hounslow.
Saunders, J.	Borough Surveyor's Office, Newark.
Smith-Saville, R. W.	Borough Surveyor's Office, Accrington.
Ward, F. D.	44, Cornbrook Street, Old Trafford, Manchester.
Young, W.	Town Hall, Salford.

TOWNS AND DISTRICTS REPRESENTED BY MEMBERS OF THE ASSOCIATION.

Abergavenny	Jon. Haigh.
Abingdon	G. Winship.
Abram	Geo. Heaton.
Accrington	W. J. Newton.
„	E. Knowles.
Acton	C. N. Lailey.
Aldershot	W. L. Coulson.
Alnwick	G. Wilson.
Alton	J. Barlow.
Altrincham	J. Stokoe.
Alverstoke	W. H. Fry.
Arbroath	J. D. Watson.
Ashby-de-la-Zouche, R S.A.	J. W. Metcalf.
Ashford	J. Willson.
Ashton-under-Lyne	J. T. Earnshaw.
Aspull	Geo. Heaton.
Aston Manor	W. A. Davies.
Audenshaw	J. H. Burton.
Aylesbury	G. Cannon.
Bacup	J. Wilson.
Barking	C. J. Dawson.
Barrow-in-Furness	W. H. Fox.
Barton-upon-Irwell (Rural)	C. C. Hooley.
Basford Union (R.S.A.)	J. Parker.
Batley	J. W. Horsfield.
Battersea	J. T. Pilditch.
Beckenham	G. B. Carlton.
Bedford	J. Lund.
Belgrave	R. J. Stephens.
Benwell	T. Dawson.
Berwick-on-Tweed	D. M. MacGregor.
Beverley	J. Beaumont.
Bingley	R. Armistead.
Birkenhead	T. C. Thorburn.
Birmingham	W. S. Till.
„	E. Pritchard.
Bishop's Stortford	R. S. Scott.
Blaby (Rural)	E. L. Miles.
Blackburn	J. B. McCallum.
Blackpool	J. Wolstenholme.
Blaina	G. Stevens.
Blaydon-on-Tyne	M. Hawdon.
Bognor	W. L. Barret.
Bolton	W. H. Brockbank.
„	J. Proctor.
Bootle-cum-Linacre	W. N. Blair.
Boston	W. H. Wheeler.
Bournemouth	G. R. Andrews.
Bowdon	J. Newton.
Bradford	J. H. Cox.
Bradford-on-Avon	J. Standfield Brun.

Bray, Ireland	F. C. Comber
Brecknock	R. Davies.
Brentford	F. W. Lacey.
Bridgewater	G. B. Laffan.
Bridlington	S. Dyer.
Brighton	P. C. Lockwood.
Brisbane, Queensland	T. Kirk.
Bristol	F. Ashmead.
Bromley	H. S. Cregeen.
Burnley	F. S. Button.
Burslem	J. E. Worth.
Burton-upon-Trent	E. Clavey.
Bury	J. Cartwright.
„	J. Farrar.
Buxton	J. Hague.

Carlisle	H. U. McKie.
Carshalton	T. L. Heward.
Cheadle	E. Sykes.
Chelsea	G. R. Strachan.
Cheltenham	G. W. Sadler.
Cheshunt	T. Bennett.
Chester	I. M. Jones.
Chesterton	D. Bland.
Chichester	H. W. Stringfellow.
Chiswick	A. Ramsden.
Clevedon, Somerset	H. Taylor.
Cockermouth	R. S. Marsh.
Colchester	H. Goodyear.
Colne	J. Mallinson.
Compton Gifford	J. C. Inglis.
Coventry	E. J. Purnell.
Crewe	G. Eaton-Shore.
Crompton	J. Mawson.
Croydon	T. Walker.
„ (Rural)	R. M. Chart.

Dalton-in-Furness	William Wilson.
Darlaston	T. W. Debney.
Dewsbury	H. F. Marks.
Doncaster	W. H. R. Crabtree.
Dorking	G. S. Mathews.
Dover	W. Thomas.
Dublin	C. Harty.
Dudley	J. Gammage.
Dukinfield	W. Spinks.
Dunoon	Jas. Collie.

Ealing	O. Jones.
Eastbourne	C. Tomes.
East Ham	W. H. Savage.
Edinburgh	J. Cooper.
Edmonton	G. E. Eachus.
Epsom	J. R. Harding.
Eston District	T. W. Stainthorpe.

Fenton	S. A. Goodall.
Finchley	G. W. Brumell.
Fleetwood	M. S. Gaulter.
Frome	P. Edinger.
Fulham	J. P. Norrington.

Gateshead-on-Tyne	J. Bower.
Gloucester	R. Read.
Goole, Yorkshire	E. C. B. Tudor.
Gorton	T. Mayor.
Grantham, Lincolnshire	S. G. Gamble.
Great Crosby	W. Hall.
Great Grimsby	J. Buchan.
„ „	J. Maughan.
Great Yarmouth	J. W. Cockrill.
Halifax	E. R. S. Escott.
Hampstead	C. H. Lowe.
Hanley	J. Lobley.
Harborne	R. Dixon.
Hartlepool	H. C. Crummack.
Harwich	H. Ditcham.
Headington (Rural)	L. Turner.
Heckmondwike	T. Gledhill.
Hendon	S. S. Grimley.
Hereford	J. Parker.
Hertford	W. H. Wilds.
Heston and Isleworth	W. B. Bromley.
Hexham	R. Grieves.
Heywood	J. Diggle.
Hinckley	W. W. Cooper.
Hornsea	P. Gaskell.
Hornsey	T. De C. Meade.
Hull	A. E. White.
Huntingdon	R. Hutchinson.
Hurst Brook	J. Heys.
Hyde	J. Mitchell.
Ipswich	E. Buckham.
Islington, Parish of	C. Higgins.
Jarrow	J. Petree.
Kearsley	T. Nuttall.
Kensington	W. Weaver.
Kidderminster	A. Comber.
King's Lynn	E. J. Silcock.
King's Norton (Rural)	R. Godfrey.
Kirkleatham	J. Howcroft.
Lancaster	A. Creer.
Leamington Spa	W. De Normanville.
Leeds	T. Hewson.
Leek	J. Myatt.
Leicester	J. Gordon.
Lewes	A. Holt.
Leyton, E.	W. Dawson.
Lincoln	R. A. MacBrair.
Littleborough	F. H. Shuttleworth.
Liverpool	C. Dunscombe.
„	G. F. Deacon.
„	G. Biddle.
Llandudno	T. T. Marks.
Londonderry, Ireland	W. J. Robinson.
Longton	J. W. Wardle.

Loughborough	Geo. Hodson.
Louth	T. W. Wallis.
Lowestoft	G. H. Hamby.
„	R. H. Inch.
Luton, Bedfordshire	W. H. Leete.

Macclesfield	J. Wright.
Maidstone	F. J. C. May.
„ (Rural)	E. P. Hooley.
Maldon (Rural)	A. Stewart.
Malton	J. L. Webster.
Manchester	J. Allison.
„	J. Newman.
„	S. C. Trapp.
„	R. Vawser.
Margam	W. Thomas.
Melton Mowbray	E. Jeeves.
Merthyr Tydfil	S. Harpur.
Middlesbrough	E. D. Latham.
Middleton (Lancashire)	W. Welburn.
Milverton	G. F. Smith.
Mirfield	F. H. Hare.
Monmouthshire (County)	W. Tanner.
Morpeth	T. W. Middlemiss.

Neath	D. M. Jenkins.
„ (R.S.A.)	W. E. C. Thomas.
Nelson-in-Marsden	W. Dent.
Neston	J. Morris.
Newark	Geo. Sheppard.
New Barnet	F. J. Rumble.
New Malden	T. L. Heward.
Newcastle-on-Tyne	W. G. Laws.
„	J. P. Spencer.
Newcastle-under-Lyme	J. Pattison, jun.
Newton Heath	J. P. Wilkinson.
Newton-in-Makerfield	R. Brierley.
Norden	Geo. Land.
Norwich	P. P. Marshall.
Nottingham	A. Brown.

Okehampton	H. Geen.
Oldbury	H. Richardson.
Orrell	G. Heaton.
Oswestry	H. T. Wakelam.
Oundle	J. M. Siddons.
Over Darwen	W. Stubbs.
Oxford	W. H. White.

Paddington	Geo. Weston.
Padiham	J. Gregson.
Pemberton	Geo. Heaton.
Peterborough	J. W. Walshaw.
Pewsey	J. Bateman.
Pinner	C. A. Woodbridge.
Plumstead	W. G. Forder.
Plymouth	G. D. Bellamy.
„	R. Hodge.
Poole	J. Elford.
Portsmouth	H. P. Boulnois.
Prescot	W. Goldsworth.
Putney	J. C. Radford.

Ramsbottom	T. Nuttall.
Ramsgate	W. A. M. Valon.
Rawtenstall	J. E. Swindlehurst.
Reading	A. W. Parry.
Redditch	S. E. Thorrold.
Rhyl	Robt. Hughes.
Richmond	W. Brooke.
Rochdale	S. S. Platt.
Rochester	W. Banks.
Rotherham	G. Jennings.
Rugby	W. Stewart.
Ryde	F. Newman.

Sale	A. G. McBeath.
Saltburn-by-the-Sea	R. A. Worswich.
Selby	T. Mallinson.
Sevenoaks	J. Mann.
Shaw	J. Mawson.
Sheffield	R. Davidson.
Sherborne	T. Farrall.
Shifnal	W. F. T. Molineux.
Skelton in Cleveland	J. W. Witts.
Sleaford	Jesse Clare.
Smethwick	J. C. Stuart.
Solihull (R.S.A.)	F. Smythe.
Southampton	W. B. G. Bennett.
„	J. Lemon.
Southgate	C. G. Lawson.
Southport	W. Crabtree.
South Hornsey	Ed. Fry.
South Shields	M. Hall.
Stafford	W. Blackshaw.
Stamford	Jas. Richardson.
Stockport	A. M. Fowler.
Stockton	K. P. Campbell.
Stoke-on-Trent	W. Bowen.
Stourbridge	W. Fiddian.
Stratford-on-Avon	A. T. Davis.
„ „	T. T. Allen.
Streatham	Jas. Barber.
Stretford	H. Royle.
Stroud	J. P. Lofthouse.
St. George, Bristol (R.S.A.) ..	Wm. Cloutman.
St. George the Martyr, Southwark	A. M. Hiscocks.
St. Luke, Middlesex	M. C. Meaby.
St. Mary, Islington	J. P. Barber.
St. Saviour, Southwark	G. R. Norrish.
St. Thomas, near Exeter	S. Churchward.
Sunderland	R. S. Rounthwaite.
Sussex (West) (County)	E. B. Ellice-Clark.
Swansea (Rural)	J. Thomas.
Swinton, Yorkshire	J. C. Haller.
Swinton and Pendlebury, Lancashire	A. H. Mountain.
Sydney, N.S.W.	R. W. Richards.

Tamworth (R.S.A.)	H. J. Clarson.
Tewkesbury, Gloucestershire ..	W. H. Gray.
Tiverton, Devon	Wm. Rowe.
Todmorden	A. Greenwood.
Tooting	Jas. Barber.

Torquay	Joseph Hall.
Tottenham	J. E. Worth.
Toxteth Park	J. Price.
Tunstall	A. R. Wood.
Turton	Jas. Parkinson.
Tynemouth	C. T. Gomoszynski.
Ulverston	Hy. Whitlow.
Ventnor	J. G. Livesay.
Wakefield	R. Porter.
Walsall	A. Hardwicke.
Walsoken	J. Kerridge.
Walthamstow	G. B. Jerram.
Walton on the Hill	S. Middlebrook.
Wanstead	J. T. Bressey.
Warrington	T. Longdin.
Waterloo, Liverpool	R. Thompson.
Watford	C. C. Lovejoy.
Wavertree	I. Dixon.
Wellingborough	E. Sharman.
West Bromwich, Staffordshire	J. T. Eayrs.
West Derby, Liverpool	E. H. Allies.
West Ham, London	L. Angell.
West Hartlepool	J. W. Brown.
Westminster	G. R. W. Wheeler.
Weston-super-Mare	A. E. Collins.
Weymouth and Melcombe Regis	W. B. Morgan.
Whitehaven	R. Pickering.
Widnes	T. Higginson.
Willesden	O. C. Robson.
Wimbledon	W. Santo Crimp.
Withington	J. Swarbrick.
Wolverhampton	R. E. W. Berrington.
Woodford	J. D. Hooper.
Worksop	J. Allsopp.
Worthing	W. Horne.
Wrexham	J. W. M. Smith.
„	A. S. Jones.
„ (Rural)	A. C. Bauch.
Wuerdle and Wardle	G. H. Wild.
York	E. G. Mawbey.
„ (Rural)	W. G. Penty.

PARLIAMENTARY COMMITTEE.

E. B. Ellice-Clark (Hove), *Chairman.*

Lewis Angell (West Ham).
Chas. Jones (Ealing).
T. De C. Meade (Hornsey).

A. Parry (Reading).
O. C. Robson (Willesden).
W. H. White (Oxford).

RULES OF THE ASSOCIATION.

I.—That the Society be named the "ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS."

II.—That the objects of the Association be—

- *a.* The promotion and interchange among its Members of that species of knowledge and practice which falls within the department of an Engineer or Surveyor engaged in the discharge of the duties imposed by the Public Health, Local Government, and other Sanitary Acts.
- *b.* The promotion of the professional interests of the Members.
- *c.* The general promotion of the objects of Sanitary Science.

III.—That the Association consist of Civil Engineers and Surveyors holding chief permanent appointments under the various Municipal Corporations or Sanitary Authorities within the control of the Local Government Board, or under the Metropolis Local Management Acts. Each Candidate for Membership shall be proposed by at least two Members, who from personal knowledge of such Candidate shall certify that he possesses the necessary qualification. Candidates residing outside England and Wales not known by two Members of this Association may be proposed by three Corporate Members of the Institution of Civil Engineers. Members who cease to hold their appointments are eligible for re-election by the Council, but will be disqualified from holding any office. Civil Engineers and Surveyors holding other chief permanent appointments under any Public Authority within the United Kingdom, or in the Colonies or Foreign Countries, shall be eligible for election as Members, subject to the approval of the Council. The Council shall also have power to elect such Honorary Members as they may see fit.

IV.—That the Affairs of the Association be governed by a Council, consisting of a President, Three Vice-Presidents, Twelve Members, and an Honorary Secretary, to be elected annually. The Past Presidents and the District Secretaries for the time being shall also be Members of the Council.

V.—That the Council shall nominate one name for President, six for Vice-Presidents, one for Honorary Secretary, and fifteen for Ordinary Members of Council. In addition to these each Member of the Association shall be at liberty to nominate one Member for the Council, but in the event of the last-named Nominations exceeding fifteen, the Council shall reduce them to that number, so as to leave thirty names in all from which to elect the required number of Ordinary Members of Council. Members' Nominations must be in the hands of the Secretary on or before the 20th of April in each year. And in case the Members' Nominations should not reach fifteen, the Council shall have the power to make up the total number of Nominations to thirty. Such list of thirty Nominations shall be printed and sent to each Member ot the Association not less than fourteen days previous to the Annual Meeting. Every Member shall be entitled to vote for or erase any of such Nominations or substitute other names, subject in all cases to the limits of Rule IV., and return the same within seven days from the date of issue. Such ballot papers shall be examined in London by the President, Secretaries, and two Scrutineers appointed at the previous Annual Meeting, or by any two of the aforesaid Members. Any Member canvassing for votes for the office of Member of Council shall be considered ineligible for election.

VI.—That the Association be formed into District Committees which shall include the whole of the Members. Such Committees shall meet from time to time, in convenient centres, for the discussion of matters of local and general interest connected with the Association. Each District Committee shall appoint a District Secretary, who will keep records of local proceedings, and communicate with the Council. All District Secretaries shall vacate their office at the Annual Meeting, and Members shall then be appointed to act as Local Secretaries until a District Meeting can be arranged, at which Meeting a District Secretary shall be appointed.

VII.—That a General Meeting and Conference of the Association shall be held annually in such towns, in rotation, as may afford convenient centres for assembling the Members.

VIII.—That each Member pay an entrance-fee of One Guinea, and a subscription of One Guinea per annum.

IX.—That no new Rule or alteration of any existing Rule be made unless Notice of Motion for such purpose and the proposed Resolution thereon be sent to the Secretary by the 31st March, and such Notice of Motion and Resolution shall be printed in the Agenda for the ensuing Annual Meeting.

X.—That Candidates successful in obtaining certificates of competency at any examination under the auspices of the Association, and who are not otherwise qualified as Members of the Association, shall constitute a class of graduates on payment of an annual subscription of One Guinea; and as such shall be entitled to attend the General and District Meetings and to take part in the proceedings thereof, and be entitled to a copy of the Minutes of the Proceedings, but shall not take part in the election of the Council. Graduates shall be transferred to the class of member when qualified according to Rule III. A graduate shall not be required to pay an entrance fee either on his becoming a Graduate or on his transfer as a Member.

ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS.

FIFTEENTH ANNUAL MEETING.

LONDON, *July* 12*th*, 13*th*, *and* 14*th*, 1888.

GENERAL BUSINESS.

THE Members assembled in the Theatre of the Institution of Civil Engineers, Great George Street, Westminster, when Mr. J. Gordon, President, took the chair, and the Minutes of the Annual Meeting held in Leicester in July 1887 were read, confirmed, and signed.

The SECRETARY then read the Council's Annual Report for the year ending April 30th, 1888.

ANNUAL REPORT.

In meeting the Association for the fifteenth year, the Council have to express their gratification at the progress which has been made during the last twelve months.

During the year more new Members have joined than in any previous year, and the papers read have been very valuable, and the meetings of a very instructive character.

The following District Meetings have been held since the last General Meeting in Leicester, on the 14th July, 1887, and the two following days. At Newcastle-on-Tyne, on the 13th August; at West Bromwich, on the 3rd of September; at Luton, on the 29th of October; at Maidstone, on the 17th of March of this year; at Lincoln, on the 14th of April; at Leamington, on the 26th of May; at York, on the 9th of June; and at Carlisle, on the 23rd of June. Although this number of District Meetings has been unusually large, their appreciation by the Members has not in any way diminished, as is testified by the attendances, by the interesting and valuable discussions upon papers of importance, and the visits to works in the several localities, from which some practical information is always gathered. In all cases, the Association has been most kindly welcomed by the Municipal Authorities, and the thanks of the Association must be gratefully placed on record, for the courtesies thus extended to them, as unquestionably the success of these meetings is in great measure due to the kindly assistance thus given us.

During the financial year ending April 30th, sixty-two new Members, consisting of fifty-two Ordinary Members and ten Graduates, have joined the Association, one Member has resigned, there has been one death, and four names have been written off. The number on the roll of the Association at the close of the year was—14 Honorary Members, 320 Ordinary Members, and 15 Graduates, making 349 in all.

The audited Balance Sheet, which accompanies this Report, shows a balance in hand on the 30th April of 369*l.* 1*s.* 7*d.* This, taken with the statement of Assets and Liabilities, shows a satisfactory financial position. The Auditors' Report will be read to this meeting.

The Ballot lists having been duly issued, the Scrutineers report the following gentlemen elected for the Council:—

President.—E. B. Ellice-Clark.

Vice-Presidents.—H. P. Boulnois, A. M. Fowler, A. W. Parry.

Ordinary Members of Council.—A. Brown, J. Cartwright, J. H. Cox, C. Dunscombe, J. T. Eayrs, E. R. S. Escott, T. Hewson, J. B. MacCallum, H. U. McKie, T. De C. Meade, R. Read, and T. Walker.

Honorary Treasurer.—L. Angell.

Honorary Secretary.—C. Jones.

Two examinations have been held during the year, the first of which took place on the 7th and 8th of October, in the Town Hall, Manchester, the use of which was kindly granted by the Corporation of that city. At this examination nine candidates presented themselves, of whom the following satisfied the examiners, and were granted their certificates:— J. Cook (Bury), T. E. W. Mellor (Stockton), J. W. Metcalf (York), W. Parker (Hereford), R. W. Smith-Saville (Accrington), and F. D. Ward (Manchester). The examiners were Messrs. Laws, Ellice-Clark, Gordon, and Boulnois. The second examination was held in London on the 27th and 28th of April, at the Institution of Civil Engineers, Westminster, the use of which was kindly granted by the Council of that body. At this examination twenty-three candidates presented themselves, and of these the following fourteen gentlemen satisfied the examiners and received their certificates:—S. W. J. Barnes (Ealing), G. H. Bayley (Salford), J. C. C. Beynon (Exeter), J. G. Bryans (Sunderland), C. H. Cooper (Wimbledon), A. Crow (Stratford), A. R. Finch (Finchley), S. N. Glass (Hackney), R. M. Gloyne (Manchester), J. Houghton (King's Norton), G. T. Lynam (Barnsley), G. P. Milnes (Wakefield), T. Pritchard (Richmond), C. L. W. Wilson (Bacup). The examiners were Messrs. Gordon, Laws, Ellice-Clark, Boulnois, and Jones. In view of the comparative numbers of candidates appearing in London and the provinces, the Council has decided to hold the examinations in London in future. The next examination will accordingly be held in London in October next.

Your Council cannot allow their Report to go forth without calling attention to the fact that one to whom we have been in the habit of looking as our leader in the sanitary world, and who has for so many years occupied the position of Chief Engineer to the Local Government Board, has retired from that honourable position, followed by the best wishes and kindly esteem of all who knew him. In tendering to Sir Robert Rawlinson our best thanks for the services he has rendered to Municipal and Sanitary Engineering, we cannot but express our hope that he may be long spared to meet us at our meetings, and still aid us by his counsel and support.

Your Council have had under its consideration the duties of surveyors in carrying out the terms of their appointment in connection with the Acts of Parliament on that behalf, and have memorialised the Local Government thereon.

During the present session of Parliament a Bill was introduced, having for its objects compulsory Registration of Engineers, Surveyors, and Architects. The Bill was fully considered by your Parliamentary Committee, who found its provisions crude and unworkable, whilst the Bill would have perpetuated the very evils it sought to remedy. Your Council therefore petitioned against the Bill, which course was also adopted by other Societies representing these professions, and the Bill was withdrawn on the second reading.

The provisions of the Local Government Bill now before the House are being carefully watched by your Parliamentary Committee.

By Rule V. as it at present stands the Council have to nominate three names for Vice-Presidents. In order to give greater choice in the Ballot list, it has been considered advisable to revert to the original number of six, and accordingly the Council now propose that this alteration should be made in the Rules.

Since the last General Meeting the Council has to regret the loss by death of S. F. Rowley of Tipton, and T. Coulthurst of Derby, the latter of whom was for several years a member of your Council.

The **President** moved, and Mr. J. **Lemon** seconded, the adoption of the Council's Report.

Mr. G. R. **Strachan** asked for an explanation why the recommendation of the Council, adopted at the Hanley Meeting in 1886, had not been carried out. It was then decided that prizes of £10 and £5 should be awarded for the two best original papers of professional interest contributed each year.

The **President** said the Council's time had been greatly occupied by most important business; but he had no doubt, now Mr. Strachan had called attention to this matter, it would be attended to in the future. There was nothing that would prevent it also being dealt with retrospectively.

Mr. **Eachus** asked what steps had been taken with respect to the Ramsgate decision. He was specially interested, as he was one of the Surveyors threatened to be attacked under it.

The **President** rejoined that this was a question of great difficulty and some delicacy. The Council had given much attention to the matter, and had gone so far as to take a legal opinion as to the liability of Surveyors when carrying out the resolutions of their Local Authorities, but were not prepared to say more than was stated in the Council's Report.

The Report of the Council was then unanimously adopted.

The **President** read the Report of the Auditors, who recommended that a notice should be issued to all Members whose subscriptions are two full years in arrear, stating that, unless the arrears are paid within one month, their names will be struck off the list of Members.

It was decided, on the motion of Mr. **Radford** (Putney), seconded by Mr. **Brooke** (Richmond), to extend the time for the payment of arrears to three months; and with this alteration, the Auditors' Report was adopted.

On the motion of Mr. **Vawser**, seconded by Mr. **Eayrs**, the whole of the Home District Secretaries were continued in office, until the next meeting of their respective Districts.

Messrs. C. H. Lowe, Hampstead; John Price, Toxteth Park; S. G. Gamble, Grantham; and J. C. Radford, Putney, were appointed Secretaries for the ensuing year.

The Auditors were unanimously reappointed, on the motion of Mr. Eayrs, seconded by Mr. De Courcy Meade.

Mr. J. Lobley proposed, and Mr. McKie seconded, a hearty vote of thanks to the retiring President for his valuable services to the Association during the past year.

The resolution having been unanimously adopted, Mr. Gordon expressed his thanks for the compliment, and then introduced the President-Elect, Mr. E. B. Ellice-Clark, Westminster.

The President then delivered his inaugural address.*

Chas. Jones, *Hon. Sec.*
Thomas Cole, *Secretary.*

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* This address and the papers read at the meeting will be found at the end of the volume.

Dr. STATEMENT OF RECEIPTS AND EXPENDITURE FOR THE YEAR ENDING APRIL 30TH, 1888. Cr.

RECEIPTS.	£	s.	d.
To Balance at Bank (May 1st, 1887)	298	6	0
„ Entrance Fees	54	12	0
„ Subscriptions	271	19	0
„ Subscriptions paid in advance	11	11	0
„ Arrears	12	12	0
„ Publishers' Sale of Proceedings	20	5	5
„ Examination Fees	91	7	0
„ Sir Robert Rawlinson	10	10	0
„ Balance of Petty Cash due to Secretary	17	7	3
	£788	9	8

EXPENDITURE.	£	s.	d.
By Portsmouth District Meeting (Expenses)	1	8	6
„ Rochester „ „ „	3	3	0
„ Leicester Annual Meeting „	10	0	0
„ „ „ „ (Report)	10	10	0
„ West Bromwich District Meeting (Expenses)	3	9	7
„ „ „ „ „ (Report)	3	3	0
„ Warrington District Meeting	2	11	0
„ Kidderminster „ „	2	2	0
„ Newcastle „ „	1	1	0
„ Luton „ „	2	2	0
„ Examiners' Expenses (3rd and 4th Examinations)	39	9	3
„ Messrs. Clowes (Printing vol. xiii.)	167	3	0
„ „ Irvine (Sundry Printing)	26	9	1
„ „ Job „	1	6	0
„ „ Cook and Hammond	5	2	0
„ „ Vacher (Lithograph)	2	15	0
„ Secretary's Salary	100	0	0
„ Petty Cash—Stationery and Sundries	17	9	0
Postages, vol. xiii.	5	5	1
„ General	14	13	2
„ Bank Charges	0	6	5
„ Balance at Bank (May 1st, 1888)	369	1	7
	£788	9	8

STATEMENT OF ASSETS AND LIABILITIES, APRIL 30TH, 1888.

LIABILITIES.	£	s.	d.
To Estimated Liability on vol. xiv.	30	0	0
„ Sundry Printing	20	0	0
„ Secretary Balance of Petty Cash	17	7	3
„ Outstanding Accounts	0	0	0
„ Examiners' Expenses Estimated	25	0	0
„ Balance	422	2	4
	£514	9	7

ASSETS.				£	s.	d.
By Balance at Bank				369	1	7
„ Subscriptions in Arrear	£97	13	0			
„ „ less 50 per cent. bad	48	16	6—	48	16	6
„ Proceedings in Stock	£193	3	0			
„ „ less 50 per cent.	96	11	6—	96	11	6
				£514	9	7

Examined and found correct, Robt. Godfrey, } Auditors.
June 8th, 1888. Geo. R. Strachan, }

Lewis Angell, *Treasurer*. Chas. Jones, *Hon. Secretary*.
Thomas Cole, *Secretary*.

DISTRICT MEETING AT NEWCASTLE.

August 13th, 1887.

Held in the Council Chamber, Newcastle-on-Tyne.

Mr. W. Geo. Laws, *Past-President, in the Chair.*

Mr. T. Dawson, Surveyor to the Local Board, Benwell, was elected Honorary Secretary for the Northern Counties District.

A vote of thanks was unanimously accorded to Mr. P. W. Thomson for his long services as Hon. District Secretary.

THE FLOATING HOSPITAL OF THE RIVER TYNE PORT SANITARY AUTHORITY.

By W. GEO. LAWS, M. Inst. C.E.

It may be interesting to the Members of the Association to have a short account of the formation, history, and work of the River Tyne Port Sanitary Authority, whose Floating Hospital at Jarrow Slake is the subject of the short descriptive paper now submitted to them.

Ships that have on board cases of fever and other infectious illnesses are, of course, a source of danger to the ports at which they call, and timely inspection and the removal of infectious cases to hospital, while the ship itself is put under quarantine, may often prevent the spread of a serious epidemic. This inspection, and the provision of the necessary hospital accommodation, is the chief duty undertaken by the port sanitary authorities of the kingdom, among which that of the Tyne is not the least active.

The Tyne Port Sanitary Authority, having informally existed since 1878, was permanently constituted under the Public Health Act in the year 1882, and consists of fifteen representatives chosen by the various riparian Local Authorities, in proportion to their rateable value thus—

Newcastle-on-Tyne	elects	6	members.
Gateshead	„	2	„
Tynemouth	„	2	„
South Shields	„	2	„
Jarrow	„	1	„
Local Boards on the north bank of the Tyne	„	1	„
Local Boards on the south bank of the Tyne	„	1	„
Total		15	

Their official staff consists of a Medical Officer of Health, Dr. H. E. Armstrong (who is also the Medical Officer of Health for Newcastle-on-Tyne); an assistant Medical Officer of Health, Dr. J. F. Armstrong; Chief Inspector of Nuisances, Mr. J. F. Taylor; Clerk, Mr. S. R. Hannay; Treasurer, Mr. J. J. Pace; and the requisite assistant staff. For the purpose of carrying on the work of the Authority, they have a chief office at the Town Hall at Newcastle-on-Tyne, and an Inspectors' Station and Offices, including a residence for the Chief Inspector at South Shields. The work of inspection of the vessels is carried on by means of a small steam-launch, which also serves to convey patients from the ships to the Hospital.

Some idea of the work of the Authority may be formed by examining the figures given in the able and interesting report of the Medical Officer, Dr. Armstrong, for the year 1886. From that report it appears that during the year, 14,080 visits of inspection had been made to 12,139 vessels, while during the eight years the Authority has been in existence, 64,658 vessels had been visited and examined. Those who may wish to know the value of that work, and the mode in which it is done, are referred to the Supplement to the 15th Annual Report of the Local Government Board (Reports and papers on Cholera, 1885–6).

The hospital accommodation now possessed by the Authority includes:—

1. A floating hospital, built on the hulk of an old steam-ferry boat, and capable of accommodating fifteen patients, having also a residence for the hospital-keeper and attendants.

2. A smaller temporary hospital for use in epidemics of cholera, which is built on the hulk of an old galliot, and will contain ten patients.

3. A smaller float, containing the hospital laundry, &c.

(All the above are moored in the river near the upper end of the Jarrow Slake.)

4. The new Floating Hospital, which is the subject of this paper, and which is intended to supersede the No. 1 hospital, now becoming unsafe from age.

In 1884, the Authority having had it reported to them that the hulk which carried the No. 1 hospital showed signs of decay, and believing that the existing provision was not large enough for the needs of the port, resolved to build a new and larger hospital, and requested the writer to advise thereon, and furnish them with designs. The original intention was to build the necessary wards (as had previously been done) on a hulk, and with this view several vessels were inspected, among others a disused gunboat, which had been offered by the Admiralty at the price of 2450*l.* This hulk, however, lay at Portsmouth, and considering the cost of bringing her round to the Tyne, and of the alterations necessary to fit her for the reception of the hospital buildings, it was considered that it would be more economical to design and build a special float, on which more accommodation could be got for the same money. The writer advised the authority in this sense, and was instructed to furnish designs, which were approved. In November 1885 contracts were prepared for carrying out the work, which was let by public tender to Messrs. Wood and Skinner, of Bill Quay.

It was originally proposed to build the float first, and moor it in its intended site, and then to erect the wards upon it, but Messrs. Wood and Skinner conceived the bold and happy idea of building the whole hospital, including the wards, on the slipways, and when complete launching the whole, and moving it bodily down the river (a distance of over 4 miles) to its present berth. Having convinced the writer that their proposal was not only feasible, but that they were able and willing to undertake the risk involved, he consented to their plan, which was successfully carried out.

To understand the difficulty of the operation, it will be necessary to give a general description of the design. The float consists of a series of ten wrought-iron cylindrical pontoons, each 72 feet long and 6 feet in diameter, with hemispherical ends. The displacement of each pontoon is 53½ tons, or a total for the ten of 535 tons. Seven rolled wrought-iron girders, each 140 feet long and 12 inches deep, connect the pontoons, being fixed to curved saddles which rest on the cylinders and are riveted thereto. The connection between the saddles and the girders resting on them, is by screw-bolts, so that any pontoon can be detached, partially sunk by admitting water, and so removed from its position for repair or painting. The distance between the centres of the pontoons when in position is 14 feet 6 inches. Across the iron girders are laid creosoted joists, 11 inches by 3 inches, 4 feet apart, which are bolted to wrought-iron chubbs riveted to the upper flanges of the girders, and across these joists again is laid a close deck of creosoted planking 3 inches thick, spiked down with 6-inch spikes. The whole forms a platform or deck, 140 feet long and 70 feet wide, which serves to carry the ward blocks, &c.

In order to prevent any tendency to racking of the float, a system of diagonal bracing of 4-inch by 3-inch T irons connects the longitudinal girders, being riveted to the under-side of their upper flanges, thus securing perfect stiffness in the plane of the deck. The whole deck, however, being thin relatively to its area, would yield partially to any inequality of support caused by heavy waves, and as an additional precaution against this, and to relieve the strain caused by the tidal current acting on the submerged part of the pontoons, four balks of timber are run the whole length of the float below the pontoons, and are secured to the iron work of the deck by 1½-inch bolts. These were not intended in the original design, but having been added for the purpose of facilitating the launching and protecting of the pontoons while being floated down the river, it was decided to retain them as likely to be still useful after the vessel was moored. The pontoons have each on their upper sides two manholes with bolted covers, for the purpose of giving access to the interior. These are reached through trap-doors in the deck above.

Access from boats to the deck is obtained by means of a sloping gangway, which at its lower end rests on a fender-beam attached to the ends of three of the pontoons, and serving to protect them from damage by the steam launch when she comes alongside. The height of the deck above water is 4 feet. The platform is protected all round by a strong wooden hand-rail, and as the main buildings do not come nearer than 2 feet to the edge of the deck, there is a narrow passage thus left all round the outside to give access for painting, repairs, &c.

The ward blocks are three in number, built of timber, and with a double skin of cleading. They are each 65 feet long, 23½ feet wide, and about 12 feet 6 inches high to eaves, and 21 feet 6 inches to ridge. The roof is of zinc, on Braby's system. It is carried on half-coupled timbers with purlins and rafters. Each ward block is divided into two wards for patients, containing six and four beds respectively; and to each ward is attached a small offshoot 8 feet square, containing W.C. and scullery. In the centre of each ward is a Musgrave's slow-combustion stove, the chimney of which is carried up through the roof, passing through a ventilating shaft 18 inches square, widening out to 3 feet at ceiling level. The stove-pipe thus does not come in contact with the wood in any part, and by its heat establishes an upward current through the ventilating shaft, which is controlled by light iron flaps worked by cords from below.

The wards are lined with pitch-pine boards dressed and varnished, and the ceiling is of the same material carried along the couples and below the collar beam. There are eight windows in the larger ward, and six in the smaller. These are each 8 feet high by 2 feet 6 inches, and have sliding sashes for two-thirds of their height, the upper third forming a swinging sash, worked by a rack and screw by cords from below, so that they can be set to any opening, and fixed by the same operation. The entrance of pure air below is effected by Kite's ventilators fixed in the walls under each bed. The ventilation is thus under complete control.

Each ward block has an independent floor laid on joists, and 9 inches above the deck, thus further providing for ventilation. The two wards in each block are separated by a space of 10 feet wide, in which is contained the nurse's room, 13 feet by 10 feet, and the bath-room, 10 feet by 9 feet.

A small window in each side of the nurse's room enables her to command a view of all the beds. In this room is placed a patent stove, formed of wrought iron and welded in one piece. This gives a constant supply of hot water by means of a circulating cistern in the roof, from which it is carried in wrought-iron pipes to the bath-room and scullery. Cisterns for fresh water, and river water for washing, are also contained in the roof, in the space above the ceilings.

The soil pipes and waste pipes discharge directly into the water outside, and are cut off short 30 inches below deck-level, so as to form an effectual air trap, and prevent any of the excreta or slops hanging about their ends. A force pump in each scullery affords the means of raising river water for washing purposes. The fresh-water cisterns are filled from water boats plying on the river. Rain tubs are so placed as to catch the roof water and preserve it for use. A small porch over the three entrance doors forms a lobby to each ward, and protects it from draughts.

The bath-room contains a lavatory with two tip basins, and a movable bath on wheels, which can in case of necessity be taken into the wards alongside the patient's bed.

The three ward blocks are arranged as three sides of a rectangle, leaving a clear deck space of 80 feet by 35 feet, on which a small administrative block will be shortly placed, containing residence for the caretaker, and kitchen, scullery, larder, store-rooms, and dispensary, with the necessary conveniences. It is intended that the caretaker only shall live on board, and that the nurses when off duty shall be accommodated on board one of the present hulks, which will be fitted up as a dormitory for the purpose. It is also proposed to fit up a light crane over the gangway, so that patients may, when necessary, be lifted out of the launch on a stretcher.

The construction of the hospital was commenced in February 1885, at Messrs. Wood and Skinner's Yard at Bill Quay, and on the 2nd of August, 1885, all was ready for the launch. Six launching ways had been laid under alternate pontoons, and the launching beams, before mentioned, braced the whole structure firmly together. All the buildings were complete in every respect, and at five o'clock, on the top of the tide, which was the highest of the year, the shores were knocked out and the vessel slid quietly and safely into the river, without the slightest shock, and without breaking even a pane of glass in the windows. When the pontoons were afterwards examined it was found that not a drop of water had entered. The success of the operation fully justified the confidence of the builders, while it reflected the greatest credit on their ability and care, to which indeed the whole structure in its excellent workmanship and finish bears ample testimony.

The hospital was at once taken in tow by two steamers, and, under the charge of a pilot, was safely conveyed to her berth four miles down the river, and there securely moored by the employés of the River Tyne Commissioners, within four hours of the launch. The berth, which is in Jarrow Slake, had been previously dredged, and the moorings laid down under the superintendence of Mr. Hedley, the Commissioners' Dredging Master.

The moorings consist of eight 1¼-inch chains, averaging thirty fathoms, each attached on the river side to screw piles, and towards the slake to beams sunk in the sand. In-board they are attached to eight double bollards securely bolted to the deck and its iron framing. Thus moored the float rides quite easily, and though so far she has only passed through the storms of one winter, yet her behaviour then was so satisfactory as to remove any anxiety for the future. The berth chosen in Jarrow Slake is peculiarly suitable, being in the centre of a wide expanse covered by water at high tide, and inaccessible at any time except by boat.

The officials of the Local Government Board have expressed themselves very favourably as to the mode adopted in the construction of the hospital, and have chosen it as their model for similar cases. (See supplement to Local Government Board Report for 1887.) The writer, however, feels, as probably most engineers do, after finishing a new work, that the experience gained has shown him many points capable of improvement.

The total cost has been as follows :—

	£
Pontoon float..	3060
Three ward blocks	2110
Dredging and moorings	530
Total	5700, or £190 per bed.

The members who propose to visit the Newcastle Exhibition this afternoon, will have an opportunity of examining the model of the float and hospital, which is exhibited there by the Tyne Port Sanitary Authority.

DISCUSSION.

Mr. **Spencer**: I have great pleasure, Mr. Chairman, in the first place, in moving a hearty vote of thanks to you for the very excellent and instructive paper which we have listened to this morning. The subject, especially to those connected with the authorities of navigable rivers, is one of the greatest importance; and I think the authorities of the part of the river with which the hospital is connected, have been the first to carry out and develop to so great an extent means for nipping in the bud epidemic diseases, or rather, I should say, for arresting the germs of disease before they reach the land and surrounding district. It is, in a place like this, easier to cope with a disease by such means as have been described, than it is to provide accommodation for stamping out the disease when it has once got a hold upon the surrounding population; and it is only by providing such very excellent accommodation as you have described to us this morning that anything approaching that object can be attained. You say, Sir, that you now see some advantages to be gained from the experience you have derived from designing and carrying out this excellent institution. I hope you will this morning give us, briefly, the benefit of that experience, if you conveniently can. If you had not mentioned it, I would scarcely have imagined any improvements could have been made, because this hospital, in my opinion, is a very suitably designed and excellent one for this purpose. The question of floating hospitals for borough sanitary authorities is one which has claimed the attention of experts and authorities for a considerable number of years; and I myself have been indirectly able to witness the efforts in this particular case since the beginning in 1878. I have, in my own experience, unfortunately witnessed a very heavy and very disastrous epidemic in this very port, and from what I saw then, I knew that if such an outbreak again occurred it would be impossible, with the accommodation existing at that time, to deal with it in the manner it ought to be dealt with. But I think from what we see and what we have heard to-day, that if such a calamity should unhappily occur again, the authorities joined together under the name of the Port Sanitary Authority will not be found behind in coping with it effectually. I do not purpose, Sir, to go into the details of this hospital. There is no doubt in my mind that it has been designed and carried out in such a manner and on such a scale, as will cause its usefulness to be not only appreciated but positively and practically useful in preventing the spread of disease in this port. This is a work which, I believe, is new in conception, and as such is, no doubt, capable of being discussed as to details; and when the designer himself, as in the present case, has been the first to see some points where improvements may be made, those matters should be taken advantage of in future cases. It is only these little advantages or improvements in detail, which we hope to get from you this morning, that are needed to complete a very interesting, useful, and practical paper. I should like to ask if it has been thought necessary in designing such a structure to make any provision for the disposal of excrement? Very possibly our friend the Chairman may think that this noble river is already in such a bad state that it does not matter what is put in it. Yet possibly, to make the floating hospital theoretically correct, it may have occurred to him to make some provision for the treatment of the refuse I have just mentioned. I am quite aware that any little drainage that may come from so small a place as this hospital, really cannot have any practical effect on a river into which the sewage of the surrounding authorities is drained. I simply put the question for the purpose of giving the Chairman an opportunity of telling us what he has done or what he would do in a similar case if it were rendered necessary. I should also like to raise the point as to refuse being disinfected. I have great pleasure in moving a vote of thanks to the Chairman, and I trust the paper will be very well discussed as to practical details as well as general usefulness.

Mr. **McKie**: I have great pleasure in seconding. I am quite sure what comes from Mr. Laws' hands will be a success. His works speak for him. I only hope those who go up to the Exhibition will have some talk with Mr. Laws over the model of the hospital, and I am sure what he says will be of great value to those who listen to him. I should like to know what is the area of cubic feet per bed; and is any separate provision made for each sex when they have recovered from a state of prostration?

Mr. **Petree**: As I am not likely to go to the Exhibition, I might point out one, and one only, detrimental point, and that is the creosoting of the deck. So far as my experience of creosoting timber goes, it is very dangerous and liable to cause fire to spread. I had to attend a fire where the flames spread rapidly, owing to the timber having been creosoted. The whole of that building was burnt down in two hours. The fact I have mentioned is the only defect which I see in connection with this hospital, and I think it would be better to avoid creosoting the timber another time.

Mr. **Brown**: I should like to know what system you have of disinfecting the clothing; whether it is conveyed on shore, or whether you have a separate vessel, and what kind of a stove you use.

Mr. **MacGregor**: There is just one question I would like to ask. It is this: If a fire were to occur on board, what means have you to extinguish it?

Mr. **Laws**: If there are no more questions, I will give a short answer to those asked me. Commencing with Mr. Brown, who asked the question as to the disinfection of the clothes: we have at present—at least the Authority has, for I am merely called in for this particular work—the Authority has a complete laundry, in which clothes are washed and disinfected. With respect to the creosoting of the timber, no doubt Mr. Petree's observation is one of some point, and it was very seriously considered by us at the time the deck was laid down. Nothing is likely to ignite more quickly, or make a worse conflagration, than creosoted timber if the air can get at it. The conclusion we came to was that it was only possible for fire to get at the upper surface. The chances of its getting hold underneath were small. We believed there was no danger of a fire getting firm hold before being discovered, and that a fire on the upper side would be no more likely to spread on a creosoted surface than on an ordinary wooden surface. Probably you have frequently noticed that it is quite possible to throw hot coals on a timber floor without its taking fire. We thought we should get twice the service out of a creosoted floor, as compared with an ordinary floor. Mr. Spencer asked that I should give some idea of what the improvements suggested by me were. The chief matter I referred to was the arrangement for taking out and painting and repairing the pontoons. At present, to get them out, we must half-fill them with water, partially sink them and draw them out. This is perfectly practicable, and a thing of almost daily occurrence on the floats of the Liverpool landing stages. It occurred to the builders when the float was being built, that the pontoons should be placed practically loose in what may be called a pair of cods, so that they could be parbuckled round in order to bring all parts successively to the surface. By this means, the chief labour in painting the pontoons would be saved altogether. The builders believed such a thing to be perfectly possible. I am inclined to think that it would be an improvement, and would feel disposed to adopt it, if called upon to design another such hospital. Another mode which, I think, would probably save a good deal of labour in moving the pontoons, is to unmoor the float, take it on to the slake when it is dry at low water, and paint it between tides. We would have something like three or four hours in which to do it, as the slake at low water stands about six feet out of water. I think we could paint her in that space of time. Whether that is practicable or not we can hardly yet say, but we mean to try it. The number of cubic feet of air space allowed per bed is between 1500 and 1800. The Local Government Board suggested that we should conform to rule, and give 2000 cubic feet per bed. We argued the matter out, on the ground that, if 2000 cubic feet is sufficient for a town hospital, surely, on a place like Jarrow Slake, with a clear sweep of 300 yards of water in all directions, some difference might be made. And they allowed us to reduce the space slightly. We could have got the 2000 cubic feet by raising the roof, and so nominally increasing the cubic space; but that does not effectually increase it. I do not believe the additional height of the roof gives as efficient space as is got by enlarging the floor-space. I have not arranged any special means of treating the sewage. In fact, we have gone upon the old principle, the object being to get the excrement from the hospital as fast as possible. We considered that, seeing the Tyne was practically an open sewer, the best plan was to have the refuse dropped at once into the river and carried away to the sea. No doubt it is rather a blot on the Tyne that it receives the sewage of so many towns; but we have the dictum of a very high authority in these matters—Sir Robert Rawlinson—who many years ago, when the Authorities here asked his opinion on the matter, said that, with such a river, and such a flow, he did not think they would ever find it necessary to adopt any means of purification before delivering the sewage into the river. His opinion has carried a good deal of weight in the Newcastle Council. The disinfection of refuse is a strong point, but, I think, could be got over in this way. We could adopt the system of putting into the wash-out basins a certain quantity of disinfectants—sulphate of iron—which would, at any rate, disinfect the refuse to some extent; that plan has been adopted in one or more places. In Nottingham, for instance, when tubs are sent to houses in which there is fever, a certain amount of sulphate of iron is put into them. Something of that kind would get over the greater part of the difficulty. With regard to dealing with fire, we have three or four small hand pumps, and I am at present, by the desire of the Authority, negotiating with Messrs. Merryweather, of London, to provide us with a special pump, so that a fire may be dealt with effectually on the first outburst. We have, besides, a certain number of hand fire-grenades. As to the separation of the sexes, there is only one sex to deal with. The patients are all sailors, and that relieves the Authority of a considerable amount of difficulty. I am not aware that there is any convalescent ward or anything of that kind. We have four floats, and we can send a patient from one to another.

Mr. Spencer's motion was then put to the meeting and carried unanimously.

The CHAIRMAN: I must thank you for the way in which you have received my rather imperfect paper. I was obliged to write it in a comparatively short time, in order to bring it before this meeting, which, for other purposes, we were obliged to hold.

During the day a visit was paid to the Exhibition, where among the many objects of interest, the Members were shown a model of the Tyne Floating Hospital, the subject of the paper read at the meeting. The detail of its construction was explained to the members by Mr. Laws, who took occasion to add such further particulars as were asked for by those who had the opportunity of seeing the model.

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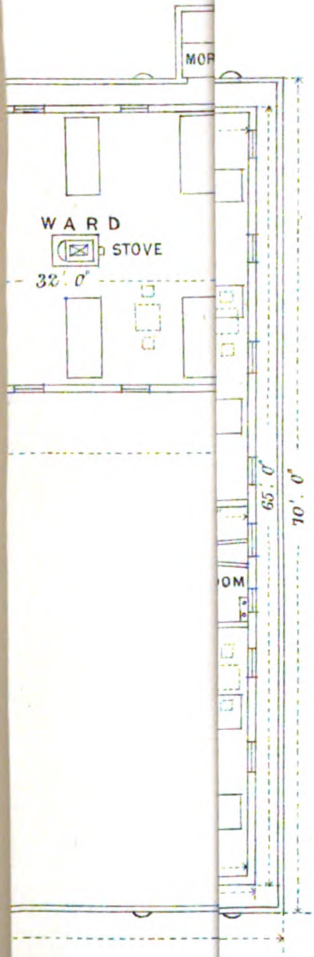

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DISTRICT MEETING AT WEST BROMWICH.

September 3rd, 1887.

Held in the Council Chamber of the Town Hall, West Bromwich.

Mr. J. GORDON, *President, in the Chair.*

REFUSE DESTRUCTORS AND THEIR RESULTS UP TO THE PRESENT TIME.*

BY C. JONES, ASSOC. INST. C.E., EALING.

IT must be taken as an acknowledged fact that there is some difficulty in constructing a suitable furnace for burning refuse, and there is little doubt that the experience of many years gained by "Fryer's Destructor" has done immense service, if not actually made this particular system a success. Turning to the several inventions brought out, it would appear at first sight that the object sought was simple and easily to be attained; but after trials, sometimes extending over two or three years, and with different kinds of refuse at different towns, they have nearly all been at last abandoned. All these trials tend to show that we must move with the greatest caution in adopting any particular process.

It will probably interest the Members of this Association if a short description be given of the various inventions that have been in use, with a few remarks upon each.

Furnaces of the ordinary type were used in London districts and the northern towns over thirty years ago, but most of these were built either by contractors or those who did not consider, in a scientific way at any rate, the action of heat, and how to utilise the small combustible portion contained in refuse to burn up the larger quantity of less combustible material. The shape and general construction of the fire-brick arches was wrong, the arrangements for feeding were bad, and the flues and passages for gases were designed more by guesswork than calculation. It is therefore no wonder that these proved to be only feeble attempts to introduce the principle of fire. It was found necessary to burn coal or other fuel in these furnaces in order to dispose of the refuse as collected, and they were ultimately used only for burning paper, straw, hampers, baskets and other light materials; several are used for that purpose at the present moment. One of these furnaces was built by the Corporation of Manchester about 1873, and many alterations were made from time to time. After three or four years' experiments (about the year 1876), Mr. Fryer, of Nottingham, appears to have come upon the scene of action and arranged with this Corporation for a trial of his furnace, which he named "the Destructor." This trial turned out sufficiently successful to induce the authorities to have another erected, and in a very short period they had no less than three large destructors built.

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* This paper was brought before, and partly discussed at, the Annual Meeting at Leicester (see vol. xiii.), its further consideration and discussion being adjourned to this, the next District Meeting in the Midland Counties.

Birmingham Corporation followed next; then came Leeds and Bradford. These destructors have been seen by most of the Members of this Association, and called forth a very able paper from our late esteemed friend Mr. Morant (May 27th, 1880). About this date Messrs. Pearce and Lupton, of Bradford, invented a furnace for dealing with town refuse, and the Corporation (of which Mr. Pearce was then a member) allowed them 50*l.* for a six-months' trial to prove *the said* advantages of their invention. These furnaces consisted of fire-brick arches, feeding hoppers and regulating dampers, with perforated fire-brick walls at the back of each cell. The invention claimed many advantages, and especially mentioned the perforated wall for dealing with offensive gases.

The trial appears to have been conducted upon fair lines. The Sanitary Committee instructed one of its officials to remain with them and note the quantity of work done, the wear and tear of cells, the amount of smoke and smell given off, and the inventors were allowed to engage their own men and work the apparatus in any way they thought proper. Although several improvements were made and a fair amount of refuse burnt, they abandoned the trial.

The next invention came from a Mr. Pickard, who had been employed by the Leeds Corporation as foreman at the Destructor works; he called his refuse destructor the "Gourmand," and it consisted of a large fire arch with two sets of furnace bars and two furnace mouths to one cell. Although there was nothing to favour this form of cell, there was certainly one part of his invention which is of the highest importance, and that is the flues and second fires; he conducted his gases from the cells down a horizontal flue and erected two ordinary fireplaces in this flue with the fires crossing it, or the fire-bars at right angles to the flue. He had exactly the first part of the principle which has so benefited the author, viz. by the action of fire the gases given off from the cells are purified; and if he had built his furnace carefully and made continuous practical trials, he would probably have adopted several other features contained in the "Fume Cremator," and thus have solved that part of the problem in advance.

Immediately afterwards Healey brought out his refuse furnace. Mr. Healey was engaged as assistant to Mr. Bryan when at Blackburn, and the erection of a "Fryer" was carried out at the time. An agreement was made with the makers, and a furnace called Fryer and Healey's destructor was erected at Bradford.

The arches and furnaces were like Fryer's, and following in the steps of the two previous inventors he attempted to purify the gases. The main arch was constructed hollow over the top, and the gases made to pass at the back of each cell, down the sides, and over the arches, and the high temperature of the arches and flues was to have destroyed the offensive gases. This, however, did not take place, and although this destructor has been altered and experimented upon at great expense, no advantages have hitherto been obtained.

Then followed Thwaites with a boiler and refuse furnace combined. It consisted of a vertical boiler with a hopper in the centre at the usual place for the chimney, and the heat of the boiling water and hot gases was said to prepare the refuse for combustion.

Then came Young, of Glasgow, with his refuse furnace consisting of an ordinary furnace with closed ashpits. Air is blown into this ashpit by a powerful fan, and combustion thus facilitated. The refuse burnt is composed of paper, straw, and light materials, and is readily consumed, whilst the cinders are picked out and burnt under an ordinary boiler. The author believes Mr. Hewson, of Leeds, made the blowing of air under the ashpits a principal part of his inventions taken out last year.

The next to enter the field was Mr. Wilkinson, of Birmingham; he had considerable experience with two kinds of furnaces, viz. Fryer's destructors and Fryer's carboniser, and it was thought his inventions would contain some advantages over those already used by his Corporation. They consisted of cells with fire-brick arches and flat fire-bars, with large double furnace mouths and a perforated wall at the back of each cell, similar to that invented by Pearce and Lupton. Mr. Wilkinson spoke so highly of their use that the Corporation of Blackpool were induced to erect one about two years ago. These furnaces have been found to cost a great deal for repairs, and will probably be abandoned and replaced by Fryer's this year.

The following is extracted from reports which are of sound practical value:—"Blackpool Council Meeting, May 3rd, 1887. Report of deputation dealt exhaustively with the destructors and cremators which had been carefully inspected at Nelson, Burnley, Bradford, Leeds, Ealing, Richmond, and London. The conclusions of the committee were as follows:—We suggest to the Council that our destructor be increased by the addition of four cells of the pattern made by Messrs. Manlove, Alliott and Fryer, such cells being placed on the back-to-back principle. We also strongly recommend that a 'fume cremator' be fixed in connection with the destructor, and that the heat be utilised before passing into the chimney."

Board of Works, Clapham.—One of our members, Mr. A. Southam, surveyor to the Board, has the following in his report of March 2nd, 1887:—"Although deputations from all parts of the country have been to see the destructors at Birmingham, I am not aware that Mr. Wilkinson's plan has been adopted excepting at Blackpool; it will therefore be necessary to obtain further information as to the relative merits of Fryer's or Wilkinson's system." On April 2nd, Mr. A. Southam reports further in reference to Birmingham, and their inspection by a deputation of his committee. He says:—"At one depôt Fryer's furnaces are in use, but at the principal yard some of the furnaces are designed and constructed by Messrs. Piercey, whilst others have been arranged and built under the direction of Mr. John Wilkinson: they are stated to be less costly than those constructed on Fryer's principle. The committee have also visited the destructors erected at Ealing and Whitechapel, which are both upon Fryer's principle, that at Ealing having as an addition 'Jones's Fume Cremator,' and they are of opinion that Fryer's destructor is superior to the Birmingham destructor."

The next inventor was Burton, who constructed a long single furnace with two fires, and the refuse was dragged through by a long endless chain, which was moved at intervals by a windlass as the refuse became consumed. It is evident that no great heat could be generated, or the chain would be burnt and the process stopped.

Then followed Stafford and Pearson, of Burnley, with the "Beehive," which is so familiar to our Members that it is unnecessary to describe its construction.

In the valuable digest prepared by Mr. Clavey, of Burton-upon-Trent, for his Board in 1886, under the head of Burnley, where the Beehive was born, in answer to the query as to whether the destructor gives satisfaction, the reply is, "It gives every satisfaction;" but on turning to Leicester, where it was in the hands of one of our most experienced officers, the reply to the same question is as follows, "the Beehive did not give satisfaction and had been demolished."

At Bradford, "the Beehive was abandoned within three months of its erection, on account of the excessive cost of working it."

Details are given in a tabulated statement supplied by Mr. Gordon as to the experiments carried out at Leicester with the Beehive, which "did not give satisfaction." Turning to Richmond, in answer to similar questions, the reply is, "They had two Beehive destructors, which did not give satisfaction, and were closed on account of several law actions." The author took the trouble to visit the Beehive destructor at Burnley, thinking that he might be induced to have one at Ealing, and the answers given above justified the opinion he then formed. Subsequently to the opening of the Beehive at Richmond, the advice of the author and of Dr. Tidy was sought by the Vestry in connection with the before-mentioned law action. It was found that the best remedy was to close them as stated above.

The manufacturer of the Beehive subsequently introduced the "Nelson." The author has no personal knowledge of this apparatus, but one was erected in the town of Nelson as a private speculation, and like the others referred to appears to have found no great favour.

When the author took out the patent for his fume cremator, and just before it was sealed, he, very much to his surprise and annoyance, received notice of objection from the patentees of the "Nelson." However, it was a matter to be attended to, and after carefully going into the question, and consulting Mr. Aston, Q.C., one of the most eminent authorities upon Patent Law, the conclusion was arrived at that they had no ground of interference; but to ascertain without a doubt the position he occupied, he requested a friend well acquainted with the whole details to take the trouble to call at Nelson and view the destructor and ascertain in what way he had interfered with them by the construction of the cremator, when much to his surprise he received an intimation from him that "alterations were being made in connection with the Nelson apparatus which would make it very much like the cremator," so upon the strength of their proposed alterations they had served notice of breach of patent. Ultimately, however, they withdrew their opposition, and nothing further has been heard from them. The following is an extract from a letter, of a few weeks since, from Mr. De Courcy Meade, referring to various destructors he had visited, and amongst others the Nelson. He says:—"In the latter, viz. the Nelson, case the apparatus was not at work, although I had previous to my visit been informed that it would be at work on Thursday, Friday, and Saturday. I called on the middle day, viz. Friday, and was afforded every information upon the subject. So far as I could judge, this apparatus is merely an experiment, and is used for burning slaughter-house offal. The dust of the town is shot on a field in the suburbs."

The Blackpool people say they carefully inspected it (the Nelson), but they do not recommend its adoption. The Huddersfield authorities also found it was only doing 4 tons per day, and suggested that it was still in the experimental stage, and from the figures given it costs 2*s.* 6*d.* per ton to destroy refuse, which is considerably more expensive than many refuse destructors already abandoned, and we must wait a considerable time before we are able to judge of the wear and tear.

Another apparatus was invented by Hardie, of Burnley, and consists of the old saddle boiler with an inclined furnace underneath, and he proposed to do away with chimneys by adopting the air-blowing principle, somewhat like Young and Co., Glasgow.

Mr. Jacobs, borough engineer of Salford, designed a furnace for burning sewage sludge, also town refuse; but from what can be gathered, the Corporation, after investigation, decided to erect a "Fryer" in preference. Its construction was upon the limekiln model, and is illustrated in a late volume of the 'Proceedings of the Institution of Civil Engineers.'

Next on the list is Odgen, of Burnley, with a refuse furnace constructed with two fires and a boiler over the top: he claims several advantages over all others; first, the burning of offensive gases by passing them through a coke fire, and also the carbonising of refuse and retaining its fertilising properties.

Finally, we have Orsfall, of Leeds, with an ordinary furnace with closed ashpit and the combustion maintained by a combination of steam and air being blown in under the fire-bars. This principle was tried in Manchester in 1876, and has been in use at Rochdale since 1881, under boiler furnaces that are burning screened refuse. There have been numerous other refuse furnaces invented, but as they have not been placed before the public, there is no need to name them.

Having detailed, so far as has been ascertained, the various destructors brought before the public, it is found that at the present time there are probably not more than about thirty of every description in use in England, varying in size from two to twelve cells, and the various models actually in use, so far as can be gathered, consist of Fryer's, Healey's, the Beehive, the Nelson, and the one at Birmingham known as the "Wilkinson." Consequently the subject appears at first sight to be one of great simplicity, but a few minutes' consideration will convince every one present who has had to deal with the difficulties that gather around this matter, that it is no easy thing to reduce into ordinary space the many questions that of necessity arise. Those who are engaged in the larger towns of England, such as Manchester, Birmingham, Leeds, and London, are fully alive to the immense difficulties which have to be coped with in settling what may be called the dustbin nuisance. Whilst our towns and the suburban parts of our districts were content, and shoots were without difficulty provided, and sanitary science had not yet distended its nostrils to gather up every whiff borne upon every wind that tells its tale of what *ought not to be*, and thousands of tons of refuse garbage were transported from our neighbourhood and dealt with as circumstances might dictate or necessity require, in somebody else's neighbourhood, it was well; but that time has passed away, and the absolute necessity of dealing with this growing difficulty has come home in a very painful manner to most of our local authorities, whether they be constituted under the powers of the Public Health Act, or the Metropolis Management Act of London.

It is during the last ten or fifteen years these difficulties have principally cropped up, and upon referring to data supplied by Mr. W. Santo Crimp, in which he includes some twenty-five towns (omitting Manchester and Birmingham, which were of still earlier date), we find amongst the early destructors erected was the one built in Leeds in 1877. The next in date is Leeds, in 1879, also Heckmondwike and Warrington in the same year. Then follow Blackburn, Bradford, and Bury in 1881; Bolton, Hull, Nottingham, and Salford in 1882; Ealing, 1883; London, 1884; Newcastle, Preston, and Whitechapel in 1886; and Bournemouth, Batley, Longton, and Battersea, with other towns, are now erecting or upon the point of erecting destructors. The details from some of these towns are herewith appended.

It was at one of the meetings of the Association at Leeds, under the presidency of the late Mr. Morant, that the author first saw Fryer's destructor, and the difficulty experienced at Ealing, not only with the house refuse but with the sewage sludge, led him to look for a remedy in the apparatus there seen at work. With the consideration which the Ealing Local Board has always shown, consent was at once given, and a 2-cell destructor was built. The author then endeavoured to settle the sludge question, and can only repeat what has been said again and again, that he found it absolutely certain in its work, and saw that he had secured a most valuable appliance, and should without difficulty rid himself of a most unendurable nuisance and continual expense. It was soon found that a 2-cell destructor was not sufficient for the purpose, and consequently the next season two more cells were erected, and at the present moment the destructor at Ealing is dealing with the sewage sludge of a population of 19,000 and the house refuse of 22,000. The adoption of this mode of dealing with sewage sludge has produced a great deal of discussion and not a little difference of opinion. This latter remark refers more particularly to the Metropolitan Board of Works, who, having heard something of what we were doing, tried some experiments for themselves, and attempting to burn their sludge in a Hoffman kiln, signally failed. Mr. Dibden states that it was the cause of offensive effluvia and could not be carried out without a nuisance; and the author cannot help expressing surprise that the Metropolitan Board of Works, with all their resources of wealth and engineering skill, should not have carried out their experiments in a more practical manner and with the best appliances that could be had. The dealing with the Metropolitan sewage was a question of multiplication of power, and the author is still of opinion that the gigantic sludge barges now being built will have to give way to a more scientific mode of dealing with the difficulty than that of carrying the sludge out to sea and there precipitating it for the benefit of the finny denizens of the deep or the unfortunate passenger vessels which may be passing through this conglomeration of London filth.

Mr. Dibden, in his paper on "Disposal of Sewage Sludge," lately read before the Institution of Civil Engineers, says:—"Before the *pressed* sludge can be burnt, the water must be driven off by heat. This involves a quantity of heat greater than that obtained from the combustion of a weight of material equal to that to be dried. In other words, expense for fuel is incurred plus the cost of pressing. When the dustbin refuse of a town is available, doubtless the object can be attained by the use of 'destructors.' The case of the Metropolitan sewage is, however, different, as no excess fuel is obtainable without considerable expense."

Further, Mr. Dibden goes on to say:—"He heard for the first time of Mr. Jones's invitations to Ealing. The facts of the case were simple. If the cost of *pressing* was prohibitory, as it appeared to be in the Metropolis, what was the use of considering the question of burning it? Mr. Jones did not contend that he could burn the *unpressed* sludge, but only the pressed. Therefore if it were decided to carry the sludge to sea, what good would be done by considering a point which could only be arrived at by first doing something which was not intended to be done? The cost of pressing the sludge of the Metropolitan sewage was far greater than in many other cases, in consequence of the additional quantity of lime required to be added to it, namely from 2 to 4 per cent., or from 20,000*l.* to 40,000*l.* per annum—a sum which would in itself go a long way in paying for the transit of the unpressed sludge to sea. No one doubted that small quantities of cake could be burnt without nuisance. It was a question of advisability, and not so much of practicability. By burning, the whole of the value of the sludge, whatever it might be, *was absolutely lost*; but when it was taken out to sea it served to manure our fishfields instead of our cornfields."

In the course of the same discussion, our esteemed President, Mr. Gordon, stated as follows:—

"Where land was available, it seemed to him that the Birmingham system of digging the sludge into the land was an exceedingly good one. He could not believe that the Ealing system of mixing the sludge with ashes and town refuse, with the object of partly drying it and then burning it in a destructor, was practicable on a large scale, although he thought great credit was due to Mr. Jones for first starting the idea and putting it into practical shape. For large centres of population, pressing the sludge, and then cremating it in this way, might be the best method of getting rid of it in all respects save one, namely, that of cost. For London, however, he could not but think the Metropolitan Board was in the right in attempting to deal with the sewage in a manner which seemed to be within the range of practicability, and in combination with the precipitating system to inaugurate the transport of wet sludge direct to sea, inasmuch as the difficulty of dealing with it in any other way by finding suitable land, or pressing it into a smaller bulk, to facilitate its transport, sale, or otherwise, would still be very great, and attended with greater expense than taking it to sea.

"He was nevertheless of opinion that, with carefully constructed furnaces and a strong draught, almost any sludge could be effectually destroyed, if a small quantity of the cheapest coal, or turf, or even cinders or ashpit refuse were used. He had little confidence in mechanical pressure being ever found reasonably economical in dealing with the enormous bulk of sludge produced in the Metropolis and the larger provincial towns."

And at the same meeting, Mr. Bennett, of Southampton, stated as follows :—

"Up to the present time he had been able to dispose of every ton, so that the works were now paying their way without making the slightest increase in the rates. The products of combustion passing through the boiler raised the steam for compressing the air. Mr. Dibden had further stated that the scheme necessitated the control of the dustbin refuse and road-sweepings by the sewage authority. In the case of Southampton that was a fact, and he thought he could show that it was a very advantageous combination of the two systems of disposal. He thought also that it would be a great improvement if the Metropolitan Board of Works would take the sole control of the ashbin contents and road-sweepings, and put an end to the system of divided responsibility that now appeared to be adopted in London; and also, instead of following the present method of destructors, in each district or parish, erect two large destructors, one destructor on each side of the Thames, conveying all the ashbin contents and road-sweepings to the outfall works, and so utilising them for obtaining some portion of the steam power for treating the sludge. Mr. Dibden had stated that one reason against treating the sewage in any other way than throwing it into the sea, was the great expense occasioned in pressing it. Mr. Bennett thought that the ashbin contents could be so burnt that power would be obtained for treating the sludge by pressing it."

The author's general reply in connection with these several extracts, applying as they do in a most important manner to the uses to which the destructor is capable of being applied, is shortly as follows. The author did not in his remarks at the Institution refer in the slightest degree to pressed sludge. Nor can he understand in reviewing his statement how Mr. Dibden could so have misconstrued them. During the years the author has been burning sludge at Ealing he has never used a press, nor has he used any other fuel in the destructor than that supplied by the house refuse. A very few days after the sludge has been pumped on to the ash beds, all the draining and drying necessary has taken place, and the material burns readily. And in further corroboration the author will read an extract from Dr. Tidy's Lecture at the Society of Arts, April 14th, 1886:—

"To my mind, the destructor has reached its highest state of perfection at Ealing, from the great thought that Mr. Jones, the surveyor of Ealing, has given to it. His sludge there is mixed with house refuse, and burnt. Mr. Jones's view is that *every town produces sufficient house refuse to burn the sludge.* One has to notice the differences of destructors. I have seen a good many myself, and I should say the differences are mainly two; first, a certain escape of offensive vapours from the shaft, and I think those offensive vapours are mainly due to partial burning—the destructive distillation, as a matter of fact, of the materials, instead of their complete destruction; secondly, the escape of fine sand and such like from the shaft at certain stages of the operation. I have seen those two nuisances very well marked, and I had occasion to advise on them on more than one occasion. I cannot help thinking myself that in Jones's destructor, where he places a muffle furnace or 'fume destroyer,' as he calls it, between the furnace and the main shaft, he has, in a great measure, met those two difficulties."

The author would now call attention to one of the most valuable papers which has appeared in the scientific world upon this question, viz. the report made by the well-known scientist Dr. William Odling, at the request of the Bradford authority, who had both Fryer's and Healey's destructor at work. Those who have gone into this question closely, know that one of the difficulties to be contended with is one springing from the sensitiveness which is felt by the authorities of almost every town when the question of smell is introduced; although no one can for a moment expect that they can go into sewage works or the dustyard of any large town and find it *smelling as sweet as lavender.* There does seem to be a very strong feeling that it is an impossibility to put up a destructor without creating an intolerable stink, and there has been admittedly some slight ground for the statement. Those of you who were in the committee room of the House of Commons upon the Kensington Vestry Bill will remember the awful and heartrending accounts given by some of the opponents of the scheme as they detailed the horrors that would arise in the erection of a destructor. This apparently happened at Bradford, and so the eminent doctor was called in to decide the question. The following is his report *in extenso*, with the author's reply.

THE BRADFORD REFUSE DESTRUCTORS.

Extracted from 'The Sanitary World,' Oct. 3, 1885.

"Dr. William Odling, of Oxford University, having been asked by the Sanitary Committee of the Bradford Corporation to make a personal examination of the refuse destructors in various parts of Bradford, with a view to advising them how to deal with the noxious vapours which arise from the burning refuse, has made the following report, addressed to Alderman Hardaker, chairman of the Sanitary Committee:—

"Speaking generally, the process consists in setting fire to the refuse as collected, and allowing it to burn itself out. This burning is conducted in long, nearly horizontal, furnaces, called destructors; the refuse, just as it is delivered by the carts, being introduced at the slightly higher end or back of the furnace, and the ash or clinkers being raked out at the front and slightly lower end, where the fire-bars are situated. It is noticeable that the burning of the refuse is carried on without resort to any fuel other than the combustible matter present in the refuse itself; and that despite the frequently wet state of the refuse, its burning in the destructors takes place steadily and completely. The burning of the refuse constitutes further an available source of heat, actually made use of at one of the stations to raise steam for the supply of an engine used for crushing and grinding the clinkers of the refuse into a valuable mortar. It is impossible for any one not to be struck with the very efficient way in which the destructors do their work, having regard to the quantity and character of the refuse they so completely dispose of in the course of but a few hours. This continuous and rapid destruction of the town refuse as fast as collected, with avoidance of all decomposing and offensive accumulations, cannot but be of great sanitary advantage to the town. It must be admitted, however, that the burning process as at present conducted is not wholly unattended with a discharge from the chimney-shaft of a little unconsumed vapour, which, under some conditions, may be recognised at a distance as offensive; but this offence, at the worst, is as nothing compared with the offence and injury to health which are so successfully obviated by the rapid destruction, daily effected, of tons upon tons of objectionable matter which must, in some way or other, be dealt with in the borough, as its deposit elsewhere would not now be permitted.

"The gases and vapours, &c., discharged from the chimney-shaft are constituted, in the main, of the completely burnt-out products of the combustion of the refuse, and would, if they were entirely so constituted, be entirely devoid of any possible offence. But, together with the great bulk of completely burned and absolutely inoffensive products, there is a small amount of unburnt and partly burnt vapours, which, by their varying proportion and character, suffice at times to impart to the chimney products generally an objectionable smell, recognisable at some distance away. Having regard, however, to the nature of the refuse burnt, it is remarkable how complete the burning habitually is, and how small is the proportion of incompletely burnt products emitted. The more or less objectionable products emitted in such small proportion are mainly of two kinds, and are furnished in two principal ways. Thus the fresh refuse, being introduced at the back and comparatively cool part of the furnace, is gradually raked down to the front and hottest part, over the fire-bars, where the burning is most active. In its course downwards to the front of the furnace it gets gradually dried by the heated products from the fire below it; and the vapours which it gives off in being thus dried escape for the most part unconsumed into the flues. The vapours so given off in the drying of the fresh refuse constitute one possible source of offence, though I do not consider them the principal source. They are composed chiefly of watery vapour or steam, and what little of them is not steam would be all but entirely lost in the large volume of completely burnt products passing up the chimney-shaft. But, in addition to the vapours given off in the mere drying, to which I attach only a minor importance, there are the vapours given off by the refuse as it just begins to burn, and before it gets into the condition of active burning, and is raked towards the front of the furnace. Every one knows the bad smell given by a piece of bone, for instance, burning by chance in an open fire. Strictly speaking this smell is not due to the actual burning of the bone, but to its state of incipient burning, or destructive distillation or frizzling by heat. Similarly the town refuse, in its state of incipient burning or frizzling, gives off what are called empyreumatic vapours, which in the furnaces as at present constructed pass at once into the flues, together with a mass of inoffensive products afforded by the active burning. It is, I consider, to the escape of these empyreumatic vapours furnished by the incipient burning of the refuse, far more than to the vapours given off by its mere drying, that any complaint of bad smells proceeding from the chimney-shaft is due.

"How to deal satisfactorily with these empyreumatic vapours, as also in the way of precaution, and for other reasons as well, with the vapours given off in the mere drying of the refuse, is not an easy matter. They are the more difficult to deal with from the circumstance that, though sufficient at times to cause offence, their actual quantity in proportion to the entire volume of gaseous and vaporous products passing up the shaft is very small. One way of dealing with these vapours would be to take means for their efficient condensation; but except as a last resource or in aid of other means, I do not recommend a resort to this method. Conducted in any way it would involve expense in plant and wages, while if conducted with a view to obtain marketable products it would involve a mode of burning the refuse differing widely from the simple, and, on the whole, efficacious method now employed, and more resembling the process sometimes employed for the distillation of shale; while the entire operation would be likely to constitute anything but a profitable manufacture. Another mode of proceeding would be to take means for preventing the formation or for ensuring the rapid destruction of these vapours within the furnace itself. Encouragement is afforded for a resort to this method by the circumstance that at the present time no attempt of anything like a practical character is made to prevent the vapours escaping unconsumed into the atmosphere, and also by the circumstance that the vapours are in their nature essentially combustible, and capable of being completely destroyed by fire. Moreover, the now dispersed heat afforded by the burning of the refuse, which might be made available to effect its own more complete burning, is shown, by its partial use for raising steam, to be in considerable excess. It is further noted that the mode of feeding the destructor furnaces with refuse is the direct opposite of that by which similar long furnaces are usually fed with fuel, and that the course of the burning is as unlike as possible the course of burning in furnaces best adapted to consume or prevent the production of smoke. Thus in smoke-consuming furnaces the fresh fuel is introduced at the front over the fire-bars, and is separated from the main flues by a length of fully-ignited fuel, over which the flame, smoke and vapour from the fresh fuel, in admixture with sufficient air introduced in various ways, has to pass on its way to the flues. But in the destructor furnaces all this is reversed, and the vapours given off in drying and frizzling of the fresh refuse pass almost directly into the main flues.

"*It would not seem advisable, however, to alter the general disposition of the present furnaces*, which are so efficient for their main purpose; but while still preserving the plan of introducing the refuse at one end of the furnace and raking out the clinkers at the other, it would, I consider, be quite practicable by some modification in detail to comply with the essential conditions fulfilled in the best smoke-consuming furnaces. Having regard, indeed, to the nature of the refuse, and to the diluted condition of the empyreumatic vapours to be combated, the problem would not be an easy one. Still it would seem that the fulfilment of the necessary conditions might be effected by one or other of several slightly different arrangements, which I have carefully considered; and if you should see fit to put me in communication with some practical furnace constructor—one or other of those by whom your present furnaces have been constructed, for example—we should, I have no doubt, be able to devise a specific construction which would be both practical and efficacious. The chief points of what I take to be requisite or desirable are as follows:—

"1. The furnaces should be of the same general form and dimensions as those at present in use. They should not, however, be built in double blocks back to back, but in single blocks, so as to be readily accessible both at back and front.

"2. The drying up of the fresh refuse in the furnaces, before its actually taking fire, should be better provided for, and the moist vapour given off by the drying, instead of being allowed to escape at once into the main flue, should be caused to pass over and through the mass of actively burning refuse. This would effect several desirable objects. The incipient burning of the refuse would, in the first place, be less and less objectionable in proportion to the dryness of this refuse. Secondly, any possible offence from the discharge of the vapours given off in the mere drying would be provided for. Lastly, the passage of the watery vapour or steam given off in the drying, through the actively burning portion of the refuse, would tend to make this portion burn with flame, a very desirable result as an aid to the destruction of the empyreumatic vapours given off in the stage of incipient burning. At present the foreman in charge occasionally delivers, with some such view, a jet of water on to the actively burning refuse, but the continuous passage through this burning refuse of the watery vapour given off in the drying of the fresh refuse would be far more efficacious.

"3. The opening into the flues leading from the furnace to the main flue should be so situated and arranged that the smoke and vapour given off by the incipient burning, together with a sufficient supply of air, should be caused, on its way into the flues, to pass over the most actively burning portion of the refuse, and thereby get almost, if not quite, completely consumed.

"4. The flues into which the products alike of the drying, the incipient burning, and the active burning first pass from the furnace on their way to the main flue should be of some length, but of no greater size than necessary, and be constructed with a view to their being maintained at as high a degree of heat as practicable. It is to these strongly heated flues that the complete destruction of any residue of unconsumed empyreumatic vapour must be entrusted. No amount of mere heating, however, will of itself cause their destruction. They must be sufficient strongly heated in admixture with a sufficiency of air in order to effect their burning or destruction. The flues serving for this purpose might also be made available to aid in some measure the drying up of the fresh refuse passing into the furnace."

"REFUSE DESTRUCTORS.

"*To the Editor of 'The Sanitary World.'*

"SIR,—In your edition of the 3rd inst., there appears a very exhaustive report by Dr. William Odling, of Oxford University, upon the 'Bradford Refuse Destructors,' dealing with the general purpose of the 'Destructor' and its importance from a sanitary point of view, and treating specially upon the one weak point, viz., the escape of the 'empyreumatic vapours furnished by the incipient burning of the refuse,' and whilst pointing out the importance of some mode being devised by which these vapours may be consumed, goes on to state that 'at the present time no attempt of anything like a practical character is made to prevent the vapours escaping unconsumed into the atmosphere, and also by the circumstance that the vapours are in their nature essentially combustible and capable of being completely destroyed by fire.'

"My object in addressing you is to point out that although Dr. Odling is most thoroughly correct in the greater portion of his remarks, and has treated the question in a most complete and perfect manner, in the first portion of the above quotation he is most decidedly, though unintentionally, wrong. In the year 1883 I constructed at Ealing a 2-cell Fryer's destructor, the first erected in the south of England; my object being to deal not only with the house refuse, but also with the sewage sludge from our precipitation works. For twelve months these two cells were worked without inconvenience; but I found that they were not sufficient for my purpose, although most successful in other respects, consequently two additional cells were added in the autumn of 1884. The consequence was that the house refuse and the sludge difficulty, so far as Ealing was concerned, came to an end. I could not, however, get away from the fact, as noted by Dr. Odling, that a certain amount of vapour was given off by the fresh fuel and passed into the flue without coming in contact with the fire. Daily watching the work with the four cells under heavy burning I came to the same conclusion as Dr. Odling has with respect to the Bradford destructor, that, complete as the apparatus is in itself, it requires something more to prevent the possibility of its becoming a nuisance, and that the only possible remedy was fire, the difficulty being the best mode of application. I decided not to interfere with the furnace, but to apply the remedy quite distinct, and after many experiments constructed a 'muffle' furnace, intermediate between the furnaces and the main shaft. Nothing could have been more successful. Everything coming from the cells, burnt or unburnt, has to pass through the intermediate furnace with the result predicted by the learned professor, absolute combustion. From a pecuniary point of view the results are gratifying, for whereas the said furnace is kept going at a cost not exceeding 1*s.* 6*d.* per day, the increased combustion gives additional steam for engine purposes, and by its increased draught assists very materially the combustion in the cells themselves. I may add that the Ealing Works have been visited by deputations from all parts of the country as well as from various parts of the Continent, and a general satisfaction is expressed with the results obtained. A patent has been taken out for the invention.

"I am,
"Your obedient servant,
"CHARLES JONES, A.I.C.E.,
"*Hon. Secy. and Past President of the Association of Municipal and Sanitary Engineers and Surveyors.*

"LOCAL BOARD OFFICE, EALING, W.
12*th October*, 1885."

Shortly after this the author wrote to the Chairman of the Sanitary Committee to which this report was made, calling attention to the fact that a mode did exist for dealing with the difficulty referred to by the Doctor.

In thus laying the report of Dr. Odling before the meeting, it is considered that more valuable information is given than the author can bring to bear upon the subject, and it certainly was in consequence of the Doctor's remarks that the author wrote to the Bradford authorities; he has since been further informed that when the Doctor's report was made, instead of trying to follow out his admirable suggestions, an attempt was made to try and carry out some improvements, but with little or no success. Mr. Healey formed drying chambers over the cells, and passed the heated gases from the newly charged cell over the hot fire of the adjoining one previous to passing them into the main flue; but owing to the small dimensions and the tortuous course of the small flues for conveying the gases from one compartment to another, the draught proved utterly insufficient, and it was evident that it was not a satisfactory experiment, as Mr. Healey, instead of erecting a new furnace, endeavoured to alter and adapt his own destructor which was unsuitable for the purpose. Nothing further has been done during the past twelve months in the direction pointed out by Dr. Odling.

It will be noticed that, from the first invention to the last, there have been attempts made to deal with the difficulties arising from the gases given off from burning refuse; and besides those named with the inventions specified, there have been many schemes tried both by the authorities who have them in use and the inventors. Fryer patented a method of water spray a few years ago; the water was distributed in a kind of shower by a revolving shaft in the centre of a chamber to which the gases were conducted like an ordinary shower-bath. Another invention was introduced by an engineer in Salford who conveyed the gases over a long water channel and baffled them with revolving discs or wheels. This invention claimed not only to deodorise the gases, but would precipitate and retain the ammonia in the water or other fluid. Mr. Hewson at one time strongly recommended this invention. All these experiments and inventions point to one end, and all of them were more or less puffed up, and several corporations were unfortunate enough to give them a trial, probably led on by the sanguine statements of the makers; but we have the evidence and experience of our fellow-engineers who have worked them, which is of the greatest value to the members of this Association, and at once gives a clear and honest account of their capacity after they have left the hand of the inventor or manufacturer. In placing these facts before the meeting, the author has endeavoured to give them in a fair and practical manner, and with a desire to call attention to those inventors who have conceived the idea of passing gases through and into separate furnaces. It will, however, be seen that most of them simply suggested an ordinary coke furnace, and the author's first experiments were conducted with a fire of this kind; and although considerable power was found in such a furnace, there were many details which required further development before practical success was attained.

An ordinary furnace was found to consume an enormous quantity of coke, and at once raised the cost of treatment to more than double, and the heat generated passed away into the chimney without utilising all its power to consume the offensive yet burnable gases. Therefore it was necessary to consider how an arrangement could be contrived which would reduce the consumption of coke and would effectually destroy offensive gases, or, in other words, a muffle furnace was wanted which could be retained at a very high temperature ready to receive the vapours and gases at any time, and keep them inside it sufficiently long to thoroughly deodorise them; and all this had to be effectually done with a small consumption of fuel and with no extra cost for labour, and with no great increase of wear and tear.

In the experiments the author found gases very similar to wind, and by baffles they were conducted in any direction; and it was proved that if they could be baffled and deflected without injuring the speed or draught, they might be kept sufficiently long in the furnace to consume and deodorise their offensive properties. It was also found that by the regulated admission of oxygen the fire could be maintained at one glowing temperature with a small consumption of coke and even breeze, and that it required very little attention. It must be left to others to say whether the author has succeeded in those very important points referred to by the following independent and disinterested authorities.

In evidence before a Select Committee of the House of Commons, Mr. T. Codrington, one of the Inspectors of the Local Government Board, said:—"He noticed improvements in many ways, and thought Fryer's with all the latest improvements was one suitable for doing its work, and considered the 'Fume Cremator' a very great safeguard against nuisance or annoyance, as it much increased the heat, and enabled a more thorough destruction of noxious gases and half-burnt paper and other things which escape."

Dr. Thos. Stevenson (Lecturer on Chemistry at Guy's Hospital, and Member of the Royal Commission on Metropolitan Sewage Discharge) said:—"If a Fryer's destructor with fume cremator was erected, it would not be possible to affect the health of the surrounding population, or cause the slightest nuisance of any kind or description."

Dr. Alfred Hill, President of the Society of Medical Officers of Health, spoke highly of the fume cremator.

Mr. R. Chamberlain, M.P., member of the Select Committee, said:—"You have taken great credit for adopting this particular plan, but the main feature of this plan, along with many others, is that you have a fume cremator with these baffles in, you superheat your products. I think the superheating is important."

Mr. J. T. Pilditch, Surveyor to the Battersea Board, reported on March 15th, 1886, that in neighbourhoods where the destructors have been fixed, complaints have been frequently made by persons residing near thereto, of the nuisance caused by the fumes and dust given off by the shaft, owing to the quick blast from the furnaces during the period of burning, and which has often been a source of trouble to the authorities in the past. Improvements have, however, been recently made whereby the smoke and other impurities given off from the furnace, and which under the old system were allowed to pass direct into the shaft and so into the open air, are now intercepted and passed through a fume cremator and consumed, thereby effectually destroying the nuisance complained of, and enabling the works to be carried on without inconvenience or annoyance to the inhabitants."

Dr. A. Newsholme, Medical Officer of Health for Clapham, reported April 6th, 1887, as follows :—

"The possibility of the escape of dust or soot or noxious gases seems to be entirely ensured at Ealing. Here not only house refuse but sewage sludge is burnt in the destructor, and yet there is absolutely no nuisance. The smoke escaping from the lofty chimney is white and thin, being much less dense than that escaping from the chimney of a private dwelling-house. This is owing to the fact that the smoke and empyreumatic fumes, on leaving the destructor, are passed through a fume cremator in which they are subjected to a temperature of 1500° F. The escape of noxious fumes is thus rendered impossible.

"The general conclusions I arrive at are that the disposal of house refuse by cremation is the best method for Clapham; that Fryer's destructor combined with Jones's fume cremator is the most efficient apparatus for the purpose."

Mr. Alfred Fletcher, Chief Inspector under the Alkali Acts, and Mr. John T. Harrison, Inspector under the Local Government Board, Mr. Alfred Fryer, inventor of the destructor, and numerous others, have spoken highly of the fume cremator; and the author can only follow their remarks by inviting the members of this Association to come at any time and judge of its merits themselves.

Finally, the results have entirely, so far as the destruction of the gases is concerned, carried out the view taken by Dr. Odling; and further, the whole of the machinery is worked by the steam obtained from this simple apparatus. The author need hardly remind engineers how valuable the results thus obtained may be where power is required, and the ease with which the power may be utilised as circumstances dictate.

Deputations from all parts of the country have visited it; scientific men at the head of their profession have investigated, by appointment and without appointment, at all times, and in every case the most direct and unequivocal testimony has been borne to its success.

The author feels sure he will be pardoned for touching upon this, as it is only by experience thus gained and imparted to others, that data can be arrived at for advising fully and freely our respective Boards.

From the mass of information the author has received upon the subject, he has chosen the following as giving the principal results of the destructor, from a report by Mr. W. G. Laws, City Engineer, Newcastle-on-Tyne (Past President), for the year ending March 25th, 1887.

NEWCASTLE-ON-TYNE.

"Ashpit Cleansing and Refuse Removal.

"In my report for the year ending March 1884, this matter was treated in some detail, and figures were given of the ascertained cost, and particulars of the mode of disposal. So many applications have been received from engineers of other towns for copies of these figures, that the report for that year ran out of print, and it has been thought advisable to repeat the information in the present report, with the necessary additions to bring it up to date.

"The subject is one of growing interest and increasing difficulty, as towns enlarge in area and population, and the value of facts and figures in the possession of the engineers and surveyors of the large towns is daily more recognised, and, when published, they are eagerly sought after. The Association of Municipal Engineers and Surveyors is carrying on a useful work in holding meetings in the chief towns of the kingdom, where papers on this and kindred subjects are read and discussed, and the actual work inspected and criticised, and the results published in their annual Transactions. New and improved systems are thus early seen and made known, and their merits canvassed by practical men, who are all working in the same direction, and what is of even more importance, failures are quickly recognised, and useless expenditure prevented in other places.

"Corporations and Local Boards who are daily spending money in sanitary works, should insist on their surveyors not only being members of the Association, but also attending their meetings, where they will get valuable information and experience which is nowhere so cheaply attainable.

"The cost of refuse removal in Newcastle, for the past year, has been 16,205*l.*, viz.:—

	£
Removal of ashpit refuse	6,476
" " street refuse..	9,729
Making a total of..	£16,205

Which represents an amount of 124,010 tons of refuse of all sorts dealt with during the year.

"This may be divided as follows:—

	Tons.	Cost.	Cost per ton.	
			s.	d.
Ashpits and night soil	79,873	6,476	1	7½
Street sweepings	19,842	7,829	5	1½
Road slurry and dust	10,634			
Box ashes	13,661	1,900	2	9½
Total	124,010	16,205	2	7¼

"The average cost of refuse removal has, therefore, been 2*s.* 7¼*d.* per ton, or,

	Cwt.	Cost.	
		s.	d.
Per head of population:— (158,000 estimated)	15·7	2	0½
Per house:— (22,900 estimated)	108·3	14	2

Which may be divided as follows per head of population and per house:—

	Per Head.			Per House.		
	Cwt.	Cost.		Cwt.	Cost.	
		s.	d.		s.	d.
Ashpit refuse and house refuse proper ..	10·2	0	9¾	69·7	5	8
Street sweepings, road slurry, &c.	3·9	0	11¾	26·7	6	10
Box ashes and shop refuse, &c.	1·8	0	3	11·9	1	8
Total	15·7	2	0½	108·3	14	2

"The refuse has been disposed of in various ways, viz.:—

"1. Sent by rail to farmers as manure.

"2. Deposited at the manure depôts, and afterwards led away by farmers, usually at a charge to them of threepence to sixpence per load.

"3. Deposited in various tips within the city.

"4. Burnt at the Byker Refuse Destructor.

"Manure has been sent by rail, as follows:—

To Chathill, on the north	46 miles
„ Prospect Hill, on the east	6 „
„ Haltwhistle, on the west	37 „

"The amount received for the sale of manure has been 148*l.* 17*s.* 5*d.*, and the cost of such sales, 64*l.*; the balance of 84*l.* 17*s.* 5*d.* has been deducted from the cost of collection, leaving the nett cost 6476*l.*, as above.

"The quantities thus disposed of have been:—

	Tons.	Tons.
MANURE—BY RAIL TO FARMERS—		
Ashpit stuff	51,490	
Street sweepings	5,250	
		56,740
Led to depôts and fields	..	9,680
REFUSE NOT AVAILABLE AS MANURE— To tips *within* the city.		
Street and road slurry	25,226	
Box ashes, &c.	6,986	
Ashpit material	18,298	
		50,510
BURNT AT THE BYKER DESTRUCTOR, from June 23rd, 1886, to March 25th, 1887—		
Box ashes	6,675	
Ashpit refuse	405	
		7,080
Total	..	124,010

"REFUSE DESTRUCTOR.

"The destructor at Byker was lighted on June 23rd, 1886, and has been burning regularly ever since. A careful account has been kept of the results of the nine months' working up to date, and the cost thereof, and is now given, viz.:—

Capital cost of 6-cell destructor, with roads and lines complete for 12 cells	£5059
Cost of working:—	£
Labour	207
Maintenance and repairs	21
	£228

"During the nine months, the amount of refuse destroyed has been 7317 tons, viz.:—

	Tons.
Box ashes and shop refuse	6675
Ashpit refuse	405
Market refuse	210
Condemned meat and infected bedding, &c.	27
	7317

"The amount received for burning private refuse delivered at the destructor, by tradesmen and others, has been:—

	Tons.	Charges.		
		£	s.	d.
Shop and other refuse	245	4	1	8
Condemned meat, bedding, &c.	27	0	9	0
Total	272	4	10	8

"The sales of clinker and ashes have been:—

	Tons.	Price.	Amount.		
		d.	£	s.	d.
To CORPORATION FOR SEWER AND STREET WORK—					
Clinker	157	4	2	12	4
Ashes	377	8	12	11	4
,, CONTRACTORS AND BUILDERS—					
Clinker	417	..	4	6	6
Ashes	204	..	7	3	4
Total	..	..	£26	13	6

"Thus the nett cost of burning 7317 tons of refuse has been:—

	£	s.	d.			
Labour	207	0	0			
Repairs	21	0	0			
				228	0	0
Less *receipts* for:—						
Material burnt	4	10	8			
Products sold	26	13	6			
				31	4	2
Nett cost				£196	15	10

And $\frac{\text{nett cost } 196l.\ 15s.\ 10d.}{\text{tons burnt } 7317} = 6\frac{1}{2}d.$ per ton.

"This, of course, does not include interest on capital, which amounts to 177*l.* per annum on the total capital of 5059*l.* If this be included, the total cost per ton would be increased to rather over 1*s.*" (*This amount evidently does not include the repayment of capital.*)

Mr. Hewson, borough engineer of Leeds, has supplied the following details; they are for the year ending August 1884, but are so comprehensive that I include them as a valuable addition to the general information.

LEEDS.

"Statement showing the cost of working the destructors, during the past year, and the quantities of materials consumed by each during that time:—

BURMANTOFTS.

Year ending August 31st, 1884.

EXPENDITURE.	£	*s.*	*d.*	RECEIPTS.	£	*s.*	*d.*
To Cost £7282 1*s.* 1*d.* repayment of debt by equal annual instalments of principal and interest during 60 years @ 3½ °/o ..	291	17	9	By Mortar	97	18	11
„ Labour for 1 year ..	585	1	0	„ Charcoal	20	9	6
„ Lime	34	18	4	„ Scrap iron	14	15	11
„ Depreciation at 2½ per cent. covering repairs	182	0	6		£133	4	4
„ Gas, water, rates, &c.	126	19	7	Balance	1087	12	10
	£1220	17	2		£1220	17	2

"For this depôt the following men are required:—

1 foreman, who acts as engine driver.
6 furnacemen, working shifts of 3 in night and 3 in day.
1 labourer, who attends to two mortar mills.

"Materials consumed during the year ending August 31st, 1884:—

Tons of rubbish	1,538
Tons of ashpit refuse	23,207
Beds	45
Mattresses	96
Pigs	58
Cows	9
Sheep	9
Quarters of bad meat	4

"Statement showing the cost of working the destructors, during the past year, and the quantities of materials consumed by each during that time:—

ARMLEY.

Year ending August 31st, 1884.

Expenditure.	£	s.	d.	Receipts.	£	s.	d.
To Cost £7466 9*s.* 10*d.* repayment of debt by equal annual instalments of principal and interest during 60 years @ 3½ %	299	6	4	By Mortar	358	7	1
„ Labour for 1 year ..	579	17	0	„ Scrap iron	16	3	8
„ Lime..	69	16	10		£374	10	9
„ Depreciation at 2½ per cent. covering repairs	186	13	3				
„ Gas, water, rates, &c.	81	1	10	Balance	842	4	6
	£1216	15	3		£1216	15	3

"For this depôt the following men are required:—

1 foreman, who acts as engine driver.
6 furnacemen, working shifts of 3 in night and 3 in day.
1 labourer, who attends to two mortar mills.

"Materials consumed during the year ending August 31st, 1884:—

Tons of ashpit refuse	20,019
Mattresses..	12
Pigs	16
Cows	1

"Total materials consumed in both destructors during the year ending August 31st, 1884:—

Tons of ashpit, &c., rubbish	44,764
No. of beds	45
„ mattresses	108
Carcases of pigs	74
„ „ cows	10
„ „ sheep	9
Quarters of bad meat	4

"At a total cost to the borough, including interest and sinking fund, of 1929*l.* 17*s.* 4*d.*, or a cost per ton of 10¼*d.*

"It will be seen from the foregoing that the destructors have proved useful for the destruction of diseased carcases and bad meat.

"It is estimated that there are still 23,571 tons of refuse collected which are not now dealt with at the destructors.

"The construction of the destructors and carboniser at Burmantofts is as follows:—

"The destructor consists of ten compartments or cells (five back to back) formed of brickwork lined with fire-bricks, and tied with iron rods; it occupies a space of 36 feet by 24, and 12 feet in height, and is so arranged that there is one inclined road leading from the adjoining road up to a platform against and higher than the top of the destructor, on to which the refuse is carted; and another inclined road leading from the same adjoining road down to the level of the firing floor, by means of which the mortar, charcoal, old iron, &c., are carted away. At the Armley Road Destructors, this low road also leads to a tip at the canal side, where manure is barged away.

"Each of the cells is capable of destroying 6 tons of refuse in twenty-four hours, and consists of a sloping furnace with hearth and fire-grate covered in by a reverberatory arch of fire-brick, with one opening at the top for the admission of the refuse, and another opening at the side near the top for the gases to escape into the flue, and a furnace frame and doors for the withdrawal of the clinkers. The refuse, which is tipped from the platform on to the top cells, is pushed down the incline or throat with a long iron prong, and slides forward on to the sloping hearth, whence, when sufficiently dry, it is helped forward on to the fire-bars, where it burns somewhat fiercely, the fire-brick arch above concentrating the radiant heat upon it. The opening for the entry of refuse is divided from the opening for the exit of gases by a partition wall, with a bridge. These prevent the refuse which is heaped up immediately below, from finding its way into the flue also. At intervals of about two and a half hours the clinkers are withdrawn through the furnace doors, but the charge of refuse is maintained permanently at the top. The effect of this is that no doors are required, the charge keeping down all smoke. The result of the process is that everything is consumed, or converted either into clinkers or a fine ash. Every two cells are also provided with an opening (with doors) for the introduction of infected mattresses, diseased meat, &c., on to the fire, where everything is readily consumed without causing a smell in the works.

"The gases from the furnaces on the way to the chimney-shaft pass through a multitubular boiler, 6 feet diameter, 10 feet in length, and make steam to drive a horizontal engine with 12-inch cylinder and 2-foot stroke, which works two mortar mills with pans 8 feet diameter. In these the clinkers made in the destructor are mixed with lime, and ground into an exceedingly strong mortar, which is readily sold at 5*s.* per ton. No fuel of any kind is required, the ashes mixed with the refuse being amply sufficient. The old tins and iron which have passed through the furnace are sold for old metal at from 5*s.* to 15*s.* per ton; but if collected and sold unburned, they fetch 1*l.* per ton, this is on account of the solder value saved by non-burning.

"The clinker from the furnaces is 25 per cent. by weight of the refuse consumed.

"The carboniser is not now used, but formerly it was used to convert the refuse obtained from the vegetable markets and other collections into a rough charcoal."

In connection with the Leeds works, the following interesting report has also recently been made: the object of the experiments was to ascertain whether the complaints made of offensive vapours, &c., from the destructors, were proved or disproved by analyses and tests of the effluent gases.

"BOROUGH OF LEEDS.

"*January* 1887.

"*Report to the Sanitary Committee of the Leeds Town Council, on the Gases and Products passing from the Destructors at Burmantofts and at Armley, as taken from the main flue leading from the Furnaces.*

"GENTLEMEN,—In accordance with the resolution of the Committee, I have made a number of tests at each set of destructors:—

"Visits were made to Armley on the 13th, 16th, and 20th December last, and to Burmantofts on the 11th, 23rd, and 29th December, and on the 10th, 17th, and 19th of this month.

"Tests were made on three days at the Armley destructor, and on three days at Burmantofts; the other visits to Burmantofts were simply visits of inspection.

"It is evident without any chemical tests that the products of combustion must vary according to the material burnt, and according to the rate at which it is attempted to burn it per square foot of fire-bar or grate surface.

"The regularity and care with which the furnaces are fed and attended to by the stokers, has also a most important bearing on the emission of imperfectly burnt products of combustion. Further, when the material to be burnt is unusually wet, the drying must take a longer time, and may involve a slower working of the furnaces than when no excess of moisture is present.

"The following are some particulars of the quantities, &c., of the gases passing from the destructors, the observations being made at the bottom of the chimney-shafts.

		Armley.	Burmantofts.
Temperature of the flue gases	average	520° Fahr.	400° Fahr.
" "	highest	650° "	460° "
" "	lowest	475° "	240° "
Approximate velocity in feet per second		32	34
Sectional area of the flue or shaft ..		27·5 sq. ft.	32 sq. ft.
Cubic feet of gas passing per second		880	1088
" " " per hour ..		3,168,000	3,916,800
Tons of air per hour		57·2	80
Tons of material burnt per hour ..		2·5	2·5
Ratio of air to material, or tons of air to 1 ton		22·8	32
Ratio of same in ordinary boiler furnaces	about	24·0	
" " with blower		18·0	

ANALYSIS OF THE GASES FROM THE DESTRUCTORS AT ARMLEY AND BURMANTOFTS, LEEDS.

"The composition of the gases varies considerably at different times, but the following may be taken as approximate averages:—

"100 volumes of the gases contain:—

	Armley.	Burmantofts.
Oxygen	17·42	18·11
Carbonic acid	2·32	1·24
Nitrogen	80·26	80·65
	100·00	100·00

"These results may be otherwise stated:—

Common air	87·10	90·55
Carbonic acid..	2·32	1·24
Nitrogen..	10·58	8·21
	100·00	100·00

"The gases also contain in minute quantity:—Sulphurous and sulphuric acids, ammonium salts, volatile organic matter, and solid particles in suspension consisting of the finest flue dust which is not deposited in the flue.

"The proportions of these substances vary very much at different times, but so far as my experiments show they are rather greater at the Burmantofts destructor than at Armley. As worked at present the latter appears to be the more efficient apparatus.

"On one occasion, when the gases were probably more impure than at other times, tests made at Burmantofts gave the following results, stated in grains per 100 cubic feet:—

Ammonia		0·1
Nitrogenous organic matter		0·6
Sulphurous and sulphuric acids		18·0
Total organic matter	about	7·0

"Part of this organic matter may be present in the flue dust which passed with the gases into the testing apparatus.

"To secure perfect destruction it would be well if the gases, before passing to the shaft, *were passed through a chamber containing red-hot fuel.*

"This chamber might be either fed with gas coke, or perhaps with the red-hot clinkers withdrawn from the destructors, which still contain some combustible matter. In the latter case, perhaps, two chambers worked alternately would be required.

"The organic matter sometimes found in the flue gases is most probably due to the drying of the materials before they are drawn down to the fire-bars to be burnt. If the material could be dried on a hot plate or bed above the furnaces, so arranged that all the air passing over the material, and vapour arising from the drying, were afterwards passed into the furnace, which would receive all its air in this way, then the risk of offensive products from the drying would be diminished or entirely prevented.

"It is very probable that the fine flue dust, which has an irritating effect on the nasal and air passages of persons breathing air containing it, is the cause of part of the complaints made respecting the destructors.

"The chamber filled with red-hot fuel would have but little or no effect in regard to this flue dust, which would be best remedied by the use of a spray of water through which the gases might be made to pass. This water spray would also tend to condense some of the sulphurous acid, and would wash and cleanse the gases. As it would also lower their temperature, efficient draught would have to be secured by special means.

"(Signed) Thomas Fairley, F.R.S.E."

EALING.

Disposal of sewage sludge and house refuse, &c., for the year ending March 25th, 1887 :—

Details of Quantities and Cost.

	Tons.
Quantity of dust, house refuse, &c., received at works during the year 1886. This includes the dust tipped direct to the destructor, about two-thirds of total amount received	3267
Quantity of sludge (after deducting 50 % for moisture drained off) produced per annum from the population of the district	4421
Total of ashes and sludge when mixed, per annum	7688
Quantity of ditto carted away by market gardeners per annum	1565
Net quantity of sludge and ashes to be dealt with by destructor	6123
Annual working expenses	£230 3 10

$$\frac{230l.\ 3s.\ 10d.}{6123} = 9d. \text{ per ton nearly.}$$

Abstract of Expenses and Receipts.

	£	s.	d.	£	s.	d.
Labour	380	0	0			
Coke breeze	36	8	0			
Repayment of loan and interest on prime cost of destructor shaft, &c. ..	115	13	4			
				532	1	4

Credits.

	£	s.	d.	£	s.	d.
The heat from destructor and cremator gives us sufficient steam to work our machinery, thus saving 6 chaldrons of coke per week. 3*l.* 6*s.* per week for 52 weeks	171	12	0			
1960 yards of hard clinker (25 % of material put into destructor) @ 1*s.*	98	0	0			
Sale of rags, bottles, &c., from dust	32	5	6			
				301	17	6

	£	s.	d.
Total working expenses	532	1	4
" saving	301	17	6
Annual working cost	£230	3	10

Gross annual expenses in connection with the treatment of sewage sludge and ashes combined:—

LABOUR.

	£	s.	d.	£	s.	d.
3 men stoking and feeding, 2 at day and 1 at night: total time .. 21 days 2 hours @ 3/10	4	1	3			
1 man screening ashes 3 „ 0 „ „ 3/8	0	11	0			
1 „ „ „ 3 „ 0 „ „ 4/2	0	12	6			
Sludge:				5	4	9
1 man loading trucks 6 „ 0 „ „ 3/8	1	2	0			
1 „ „ „ 6 „ 0 „ „ 3/4	1	0	0			
				2	2	0
				£7	6	9

The foregoing represents the house refuse and sludge, which, taken together, give

7*l.* 6*s.* 9*d.* × 52 weeks = 381*l.* 11*s.*, say 380*l.*

The above statement as to labour includes more than should really be charged to the destructor, as the men are engaged part of the time in the yard, pumping out and other general work. Half the foreman's time is also charged to destructor.

For about six weeks in the year the fires are banked up, and there is little labour on the destructor; but no credit is taken for this; nor is there for the hard core from dust, such as tins, &c., although the labour of picking over is charged in "expenses."

The furnaces are seldom banked up on Sunday, but when this is done the furnaces are filled with refuse and the dampers nearly closed.

Cost of destructor, &c.:—

	£	s.	d.	£	s.	d.
Chimney-shaft	730	0	0			
Cost of 4 cells, fume cremator, and boiler	1270	0	0			
				2000	0	0
Repayment of principal and interest per annum on 100*l.*, 30 years at 4 %				5	15	8
Repayment of principal and interest on 2000*l.*				115	13	4

Two of our cells and the cremator were built out of current account and not out of loan, so there are no annual repayments in respect of these, but the author has included the cost in above amount. For the destructor itself, no machinery is necessary, but of course if it is desired to utilise the heat given off to raise steam, a boiler is required. Other machinery of course depends upon the requirements of the works. At Ealing there is a 6 horse-power engine which drives the liming machine, clay mixer, works lift, chain pump, special pump, &c., atmospheric ejector, sludge ram and mortar mill, &c., and there is steam sufficient to work all the above, and additional machinery if required.

At the present time a considerable saving is being effected by using the hard clinker as a base for tar paving, thereby causing a saving of 30 per cent. Also on a concrete paving, which can be laid for 3*s.* per yard sup., York paving costing 6*s.* 4*d.* per yard sup. The finer material from ashpit, which contains a good deal of recalcined lime, makes a splendid mortar mixed with 1 part of lime to 5 of ash, and the clinker when ground makes a good mortar with usual proportions. In the above account no special credit has been taken for these items.

BURY, LANCASHIRE.

The borough engineer, Mr. J. Cartwright, supplies the following details of the working of 4-cell destructor for the year ending March 31st, 1886:—

Total cost of destructor shaft, high-level road engines, mortar mill, &c.	£3500
Total number of tons of refuse burnt	6326

A staff of four men are employed, 2 at night and 2 in the day. Wages 26*s.* per week.

	£	*s.*	*d.*
The total cost of working the destructor for the year has been	438	15	6½
Credit by profit upon sale of mortar	103	10	1½
	£335	5	5

Abstract of Expense.

	£	*s.*	*d.*
To annual cost upon working	335	5	5
„ repayment of principal and interest in (say) 30 years at 4 per cent. upon 3500*l.*	202	8	4
	£537	13	9

$$\frac{537l.\ 13s.\ 9d.}{6326} = 1s.\ 8\tfrac{1}{2}d. \text{ per ton.}$$

HECKMONDWIKE, YORKSHIRE.

Mr. T. Gledhill, town surveyor, supplies the following details of the working of a 3-cell destructor for the year 1886:—

Number of loads destroyed..	1796
Entire cost of destructor, including high-level road, chimney-shaft, mortar mill, boiler, engine, &c. ..	£1512 0 0

	£	s.	d.
Repayment of loan and interest	118	17	6
Gas rates and general repairs	10	0	0
One man at 25*s.* per week	65	0	0
„ „ half time at 22*s.* per week	28	12	0
Cleaning boiler, flues, and insurance	6	0	0
Paid for lime	14	8	0
	£242	17	6

ABSTRACT OF EXPENSE AND RECEIPTS.

	£	s.	d.
As per statement of expense	242	17	6
Credit per sale of old iron, mortar, &c.	83	1	6
	£159	16	0

$$\frac{159l.\ 16s.\ 0d.}{1796} = 1s.\ 10d. \text{ per load.}$$

Mr. Gledhill adds: "The destructor was erected under my supervision, and I have had the management of it since its construction (1879). I can testify to the efficiency of the destructor at Heckmondwike, and do not know what we should do with our refuse if we had no destructor."

The following is an extract from the report of the Sanitary Special Sub-Committee of the borough of Huddersfield. Most of the towns in which destructors have been erected were visited by this Committee and the Borough Engineer Mr. R. S. Dugdale, and full particulars obtained. The summary of the information obtained is from thirty-one towns, twenty-seven of them being towns referred to in the Registrar-General's Returns.

REPORT TO THE CORPORATION OF HUDDERSFIELD.

"1. *Population of District.*—This ranges from 15,000 to 545,320.

"2. *Area of Ditto.*—From 406 to 18,499 acres.

"3. *Rateable Value of Ditto.*—From 40,000*l.* to 3,395,804*l.*

"4. *Number of Towns in which Destructors are established.*—Twenty-two: of which twelve have adopted Fryer's Patent; two of them, Birkenhead and Burnley, the 'Beehive' type; one, Nelson, Richmond and Co.'s; and three, Glasgow, Birmingham, and Manchester, their own design. The aggregate number of cells being 149 and four carbonisers. Manchester has, in addition, thirteen destructor boilers by Galloway and Sons.

"5. *Number of Towns having Destructors capable of cremating Ashpit Refuse.*—Sixteen. The two destructors incapable of this are at Birkenhead and Burnley.

"6. *Proportion of Population served by Destructors.*—This varies from one-fourth to the whole.

"7. *Number of Tons of Refuse destroyed per Day.*—From six to seven tons per cell per working day of twelve hours.

"8. *Reduction in Bulk and Weight.*—To about 25 per cent. and 33 per cent. respectively.

"9. *Employment of Residuum.*—In road foundations, making mortar, and filling hollows in land.

"10. *Difficulty in disposing of Old Iron, &c.*—This question is answered about equally in the affirmative and negative.

"11. *Distance which Refuse is carted to Destructors.*—This may be set down at 1½ miles.

"12. *Contiguity of Dwelling-houses to Destructors.*—Dwelling-houses and works are contiguous to several of the destructors.

"13. *Complaints.*—Out of the eighteen towns possessing destructors, seven have had complaints regarding them, but with the exception of Bolton, none of these seem to have had a more serious result than to cause means to be adopted for burning the gases before they pass into the chimney.

"14. *Height of Chimneys.*—This varies from 60 feet to 260 feet. One chimney only is 60 feet, viz. that at Nelson, where the works are, as yet, more or less experimental. No doubt local circumstances and requirements determine height of chimney.

"15 and 16. *Cost and Royalty.*—Answers to these queries differ so far as to be of little use to the Committee.

"17. *Number of Men and their Wages.*—Apart from attendance at mortar mill or other machinery, it may be taken that five, or at most six cells, require two firemen. Rate of wages varies.

"18. *Utilisation of Waste Heat.*—In eight cases the otherwise waste heat is utilised for generating steam for motive purposes connected with the works.

"19. *Circumstances which led to adoption of Destructors.*—In most cases the difficulty of finding tips for the refuse, or other means of disposing of it.

"20. *Deposit of Ashpit Refuse on Building Land.*—In many cases ashpit refuse has been deposited upon building land, and in some of the towns this is still done. Complaints, however, appear to have been frequent, and in certain of the towns a layer of concrete 12 inches thick over the site of intended buildings is exacted. In others the refuse is covered with virgin earth to a considerable depth.

"21. *Closet or Privy system in Use.*—This is marked by variety, and embraces nearly every kind from the primitive privy and midden to the modern W.C., several thousands on the pail system, with its dry ash-pits, being amongst the number."

The committee further state that "a properly constructed destructor need be no nuisance."

No reliable information can be given as to cost of erection, it being so much affected by site, height of chimney, level of ground, &c. In some cases it may be necessary to construct an inclined road to top of furnaces, in other cases the ground may be so situated as to render this unnecessary. Then with reference to the chimney. The cost varies very much for this class of work, but would probably be nearly 30 per cent. cheaper in the north of England than in the south, for whereas the cost of a shaft at Leeds 150 feet high is given as 474*l.*, the one at Ealing (Middlesex), only 143 feet in height, cost 700*l.*

In some towns the residuum from destructors is ground into mortar and sold ready for use at prices varying from 5*s.* to 7*s.* per ton; at Bury, where 5*s.* per ton is charged, the estimated profit in 1886 was 103*l.* 10*s.*

The author finds a very considerable difference in the cost of burning per ton of refuse; this is also dependent very much upon original cost, also upon quantity consumed. To give an approximate idea, he has taken the following towns as examples:—

			Per Ton.	
			s.	*d.*
Bury	6,000	tons burnt in the year.—Net cost of burning	1	0¾
Ealing	6,000	" " " " "	0	9
Heckmondwike	2,000	" " " " "	1	10
Newcastle	7,317	" " " " "	1	0
Leeds	44,764	" " " " "	0	10¼

These several amounts (with the exception of Newcastle, see Report) include repayment of principal and interest, allowance being made for profit derived from sale of mortar, &c., the variation in cost arising almost entirely from difference of repayment. In the case of Ealing the destruction of sludge must be taken into consideration in any comparison made; at the same time it is only right that attention should be called to the credit taken in the account of profits upon the Ealing Works in the matter of steam. The author considers this a perfectly legitimate credit, an absolute saving being effected in coke, the said coke being for engine work connected entirely with the sewage works, and not with the destructor, as is the case in the Leeds and other works, where the power is used in working mortar mills, a credit being taken in the accounts for mortar sold.

LEICESTER.

Data Supplied by J. Gordon, Esq., C.E., relative to the working of the Beehive Destructor.

Date.	Refuse burnt.	Ashes remaining afterwards.	Actually consumed.	Coals used.	Coke used.	Hours burning.	Labourers' time.	Cost.				
								Coke.	Coal.	Labour.	Cartage.	Total
	Ton cwt. qrs.	Ton cwt. qrs.	Ton cwt. qrs.	Ton cwt. qrs.	Ton cwt. qrs.	Hrs.	Hrs.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Sept. 4 to 8	16 10 0	7 5 0	9 5 0	0 4 2	1 4 2	..	45½	0 11 0	0 2 10	0 18 11½	0 7 6	2 0 3½
„ 9 & 10	5 19 2	2 19 2	3 0 0	0 2 0	0 10 2	16½	32½	0 4 9	0 1 1	0 13 6½	0 3 0	1 2 4½
„ 15 to 20	33 13 2	18 15 2	14 18 0	0 7 0	2 1 0	119	129	0 18 6	0 4 3	2 13 9	1 3 6	5 0 0
Oct. 14 to 18	20 0 0	10 0 0	10 0 0	1 5 0	0 6 0	63	67	0 2 6	0 7 6	1 7 11	0 7 0	2 4 11
„ 20 to 24	24 8 0	17 5 0	7 3 0	0 17 2	0 9 0	94½	99½	0 3 9	0 5 4	2 1 5½	0 14 6	3 5 0½
	100 11 0	56 5 0	44 6 0	2 16 0	4 11 0	293	373½	2 0 6	1 1 0	7 15 7½	2 15 6	13 12 7½

Cost per ton destroyed, 2*s.* 6*d.*

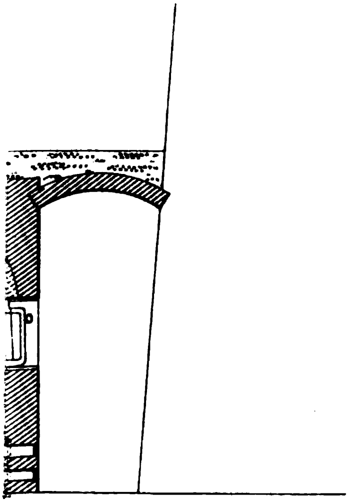
WIMBLEDON LOCAL BOARD.

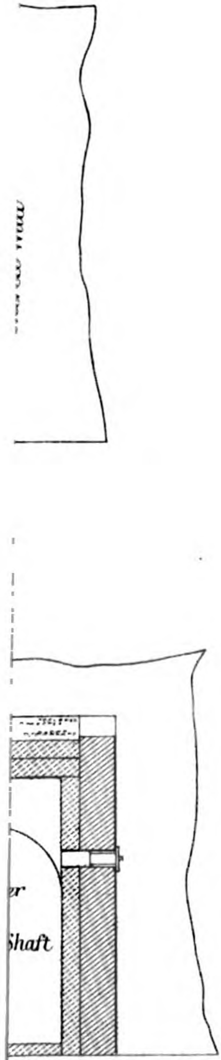
DETAILS SUPPLIED BY W. SANTO CRIMP, ESQ., C.E.

Name of Town.	Date of erection of Destructor.	O. D. level of site.	Height of shaft (in feet).	O. D. level of highest inhabited part of District within one mile.	Distance of nearest dwellings (in yards).	Any complaints of dust or smell.
Batley	Have just obtained sanction to loan for Destructor.					
Bath	Plans now before Committee.					
Battersea	Tenders for Destructor being advertised for.					
Blackburn	1881	430	105	625	110	Yes, from smell when burning fish offal, &c., but now have a Cremator.
Bolton	1881–2	320	180	475	50	No.
Bournemouth	Destructor is in course of erection.					
Bradford	1881	450	180	670	200	Occasionally.
Burslem	Tenders for Destructor just been invited.					
Bury	1881	350	180	405	200	Not from dust: used to from smell.
Cheltenham	Are purchasing site for Destructor.					
Derby	1882	150	160	250	300	No.
Ealing	1882	30	143	100	50	Not since "Cremator" has been in operation.
Heckmondwike ..	1879	180	..	450	40	No.
Hornsey	Land has just been obtained for Destructor.					
Hull	1882	Borough is level			80	No.
Longton	Destructor in course of erection.					
Leeds	1877	225	150	300	60	No.
Do.	1879	112	120	300	30	Complaints of dust occasionally.
Rochdale	1882	401	250	600	160	No.
Newcastle-on-Tyne	1886	184	150	204	70	No.
Nottingham	1882	82	160	190	150	No.
Preston	1886	117	180	140	40	No.
Salford	1882	102	180	139	150	No.
Warrington	1879	27	120	50	1000	No.
Whitechapel	1886	49	180	50	5	Dust occasionally (not from chimney)

In bringing this paper or compilation of details to a close, the author would express a hope that the information given may prove of some value to his brother-officers in dealing with this important subject. When our esteemed President, J. Gordon, Esq., M.I.C.E., at the end of the Portsmouth meeting in June last, made request that I would prepare a paper for the Annual Meeting upon the question of 'The Destructor and its Results,' it must be admitted that in giving my consent I lost sight for the moment of the large amount of information it would be necessary to obtain, and the very short time in which to do it. These difficulties were, however, overcome by the extremely kind way in which all to whom application was made, responded to my request; and I take this opportunity of expressing my sincere thanks, not only to my brother-officers whose names appear in the paper, but to all those gentlemen who supplied me with information which, for want of space, I have been unable to make use of.

ED.

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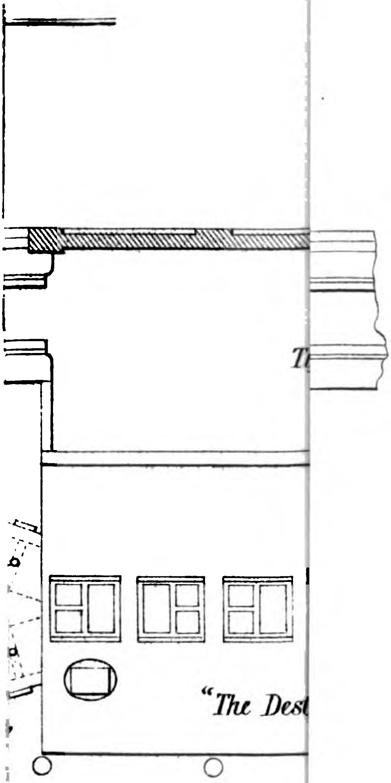

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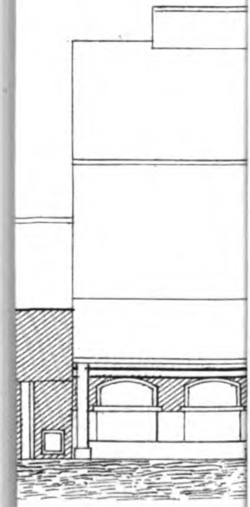

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APPENDIX.

HORNSEY.

At the Hornsey inquiry, held by John Thornhill Harrison, Esq., C.E., the following important evidence was given:—

(*Extract from Shorthand Notes.*)

"Dr. Tidy was then examined.

"Mr. Littler, Q.C.: I believe, Dr. Tidy, you have devoted your life to the study of sanitary matters?

"Dr. Tidy: Yes.

"Mr. Littler: And you are aware of the systems of improved destructors, such as Fryer's, and especially cremators?

"Dr. Tidy: Yes, and I believe I have seen all the destructors in England.

"Mr. Littler: Now, even where there is no cremator, I think you will agree with me that there need be no nuisance.

"Dr. Tidy: I think it possible to manage them without, but, I confess, with some little difficulty. The point is this: with the burning of organic matter, one of two things happens; you either get what is called destructive distillation, which is burning at a low temperature, without any danger, but offensive products may be produced; or you burn completely, by having your furnace at a high temperature, and then the only products are carbonic acid and water. What is important to me is, that with a cremator you must burn completely, and you then get all your matter reduced to carbonic acid and water.

"Mr. Littler: Which is perfectly innocuous?

"Dr. Tidy: Perfectly.

"The Inspector: What is the temperature in the cremator?

"Dr. Tidy: Fifteen hundred degrees is easily reached. I have been on many occasions to Ealing, and I have never yet found the temperature fall below that necessary to convert the refuse into carbonic acid and water.

"Mr. LITTLER: About eleven hundred degrees is enough for that, I believe?

"Dr. TIDY: Yes, but fourteen hundred to fifteen hundred degrees is perfectly certain.

"Mr. LITTLER: Do you consider a destructor the best method of dealing with house refuse?

"Dr. TIDY: I consider the destructor, with the cremator, an enormous advantage in sanitary work.

"Mr. LITTLER: And of course, with the matter in the hands of the Local Board, they will be able to take the organic and other offensive matter and dispose of it at once, without nuisance or injury to the New River Company or anyone else?

"Dr. TIDY: Certainly.

"Mr. LITTLER: And in a place like Hornsey, where there are proper water-closets, there will be no fæces?

"Dr. TIDY: Yes; but even if there was there would be no smell. In Ealing a great deal of such deposits come through. The sludge and even pieces of brick are put in, but they can all be dealt with without difficulty or nuisance.

"The INSPECTOR: Have you examined the gases from that at Ealing?

"Dr. TIDY: Yes, and the result is entirely carbonic acid and water.

"Mr. LITTLER: And if there was carbonic acid in this room it would not hurt?

"Dr. TIDY: No; but that is entirely different, because it would be confined, but in the open it would be diffused through the air.

"Mr. LITTLER: I think that is all I need ask you, Dr. Tidy."

Mr. ANDREWS, C.E., of Bournemouth,—where a four-cell destructor and cremator has lately been erected,—was then examined and gave most satisfactory evidence.

EALING.

In the autumn of this year I received instruction from my Board to proceed with the construction of two additional cells to the destructor. This necessitated a slight increase in the length of the "Fume Cremator," about 2 feet 3 inches being added to the length shown in Plan annexed. This addition has proved of immense value, the results being most satisfactory; for although the fire is less concentrated than formerly, I obtain a larger and better-spread bed of *red-hot fuel.* Combustion is of necessity more complete, frequent firing is avoided, and the gases have a greater length of furnace to traverse, whilst the heat, if not quite so intense as formerly, is more than sufficient to accomplish the object desired. A very slight additional cost for breeze is incurred, and a considerable increase of power may be obtained if required.

The eminent scientist, Professor J. A. Wanklyn, was requested to visit and report upon the above: I append his report:—

" LABORATORY,
" 7, WESTMINSTER CHAMBERS,
" LONDON, S.W.

"On 9th December 1887 I paid a visit to the Ealing (Southern) Sewage Works, where all the house refuse and nine-tenths of the sewage from the Ealing district (population, 22,000) is dealt with.

" At these works there is in operation a four-cell 'Fryer's Destructor,' together with certain adjuncts designed by Mr. C. Jones, C.E., the engineer to the Ealing Local Board. 'Jones's Fume Cremator' especially attracted my attention. Readings of the temperature were made at the time as follows:—

In passage from Cells to " Fume Cremator "	610°	Fahr.
In " Fume Cremator "	1270	"
After leaving " Fume Cremator "	1100	"

" At these temperatures, and in presence of the accompanying air, all septic poisons are destroyed, and organic compounds are resolved into carbonic acid, water, and nitrogen gas; only the minutest traces of empyreumatic products could survive and pass away through the shaft into the general atmosphere. No harm to the health of the community is to be expected or feared from these products.

" J. ALFRED WANKLYN, M.R.C.S.,
" *Professor of Chemistry.*

" *12th December*, 1887."

DISCUSSION.

The President: As the time is very short, and we have already largely exceeded what was to have been devoted to our visits elsewhere, I must beg of you to direct your attention to the subject we have to discuss. It is, as you know, the paper on "Destructors," read by Mr. Jones at the Annual Meeting of the Association at Leicester. In introducing the subject, I think it will be well probably if I read a letter or two I have received from gentlemen who are not able to be present with us this afternoon. The first is from Mr. Ellice-Clark. He says:—

"I regret that engagements will prevent my attending at West Bromwich, which I should have had much pleasure in doing, so as to pay my respects to Mr. Eayrs, one of the most energetic of Municipal engineers. I see you are going to discuss Destructors. I have not had much experience on this question, but, speaking generally, I can conceive no more serious waste of fuel and nitrogenous matter than consuming the ash remains of coal, to convert decaying 'refuse' into gases, which in their turn pollute the air. Instead of the Association of Municipal Engineers discussing the readiest method of using up the residual carbon for the destruction of a manure base, it might be seriously engaged in considering the more economical consumption of coal in domestic dwellings. The enormous waste of fuel which now takes place, amounting to so much as 60 and 70 per cent., is a reproach to our profession. Still more so the 'destruction of refuse,' when our exhausted soils are passing out of cultivation for want of a cheap nitrogenous fertilizer. It will be contended that the municipal engineer has no time to enter into a question of this sort. I cannot conceive that such is always to be the case. I hope and believe the municipal and sanitary engineer has time to enter into this question, which is essentially both sanitary and economic. I hope and believe the municipal and sanitary engineer of the future will look on "Destructors" with the same eyes and emotions that we have for a hatchet of the Stone Age."

The next letter is from a gentleman I am exceedingly sorry is not here to-day, who has prepared some facts and figures relating to the subject we are to discuss to-day, Mr. Laws, of Newcastle. He says:—

"I am prevented at the last moment from coming over to the discussion on Destructors, by a meeting being fixed for to-morrow, which I must attend. It is vexatious, for my bag was packed. I have not time even to write down anything for you, but, as a trifling contribution, send the financial results of first twelve months' working as made out for Mr. Codrington. I have kept a very careful account of the matter, in order to have a perfectly unbiassed record, facts being worth more than opinions. We are about to make some experiments shortly on 'Temperatures of Flues,' 'Constitution of Gases,' &c., which will in due time be laid before the Association."

The papers and facts which Mr. Laws sends as his contribution to the discussion are as follows:—

"I have pleasure in sending you the particulars of the twelve months' working of the Newcastle-on-Tyne refuse destructor. This you will see, including all material and repairs, and deducting all receipts, leaves the nett cost of burning at 6·8*d.* per ton. In calculating the further amount due for interest and redemption, I have taken account of the fact that 1400*l.* of our present expenditure would not have been necessary but for the intention of extending the structure to twelve cells. The nett capital cost, therefore, applicable to the present six cells is only 3,640*l.* out of the 5,040*l.* expended. Taking the interest on capital at 3½ per cent., and the redemption in twenty-five years at 4 per cent., this brings the total cost up to the figures herein, viz.:—13·3*d.* per ton burnt. This, however, is scarcely a fair way of putting the cost, as, of course, the interest decreases year by year, and in twenty-five years the redemption will cease. The fairest way appears to be to take 5 per cent. upon the capital expended, which amounts to 4·35*d.*, thus making the cost of burning a little under 11¼*d.*

"REFUSE DESTRUCTOR, BYKER.

	£	*s.*	*d.*	£	*s.*	*d.*
Capital expended up to date	5040					
Of this, £1400 in view of future extensions	1400	0	0	3640	0	0

		d.
Working expenses per ton burnt	.. ..	6·80
Interest on capital 3½ per cent.	.. ..	3·05
Redemption of capital „	(25 years)	3·48
		13·33

WORKING ACCOUNT.

FROM 29TH JUNE, 1886 TO 29TH JUNE, 1887.

	£	s.	d.	£	s.	d.
Labourage	298	1	7			
Material	32	4	11	330	6	6

RECEIPTS.

		£	s.	d.
Products sold, ashes, scars, &c.	1572 loads	39	8	9
Receipts from private parties for tickets for burning refuse		6	5	0
		45	13	9

		Tons.
No. of loads of refuse burnt	9,124 loads	
Equivalent to		10,036

Average 32·2 tons per day.

	£	s.	d.
Total cost for 12 months	330	6	6
Receipts for „	45	13	9
	284	12	9

Nett cost of burning 10,036 tons of stuff = 6 8*d*. per ton."

I have also a letter from Mr. Strachan, of Chelsea, but I will not read it unless the meeting wishes it read. I have not had time to communicate with Mr. Strachan, or I would have pointed out to him that I think the remarks are hardly such as he would have made if he had been present. A great deal he has written here might fairly be the subject of controversy, but no doubt it will appear in a somewhat modified form in the report of our proceedings. At the same time I feel that, having regard to the remarks I made at Leicester, in my introductory address at the annual meeting, Mr. Strachan scarcely confines himself to the line of argument I always hope to see observed in the discussions of this Association.

Mr. DE COURCY MEADE: This is such an exhaustive paper, and the subject has been dealt with so fully by Mr. Jones, that, as we have now only about nine minutes left, I think it would be well if we adjourned the discussion until the next district meeting, although I see some of our members present who have had practical experience of refuse treatment for eight or nine years. The cost of burning as given by Mr. Jones varies from 9*d*. to 1*s*. 10½*d*.

per ton; and I think if the Metropolitan vestries were to see a few of these furnaces at work, and were satisfied that the work could be done for the amount named by Mr. Jones, and without nuisance, the present system of dealing with the Metropolitan refuse would very soon be abandoned. I have taken a very great deal of interest in this subject, and reported on it very fully three and a half years ago, and my Board have the question before them now. I think it would be a pity to close this discussion this evening, and I would therefore suggest that it should be deferred until the next meeting.

Mr. **Walter Brooke**: I quite agree with Mr. Meade that it would be well that this discussion should not be closed to-day, seeing there are some members present who may desire to say something on the subject now. After I had made some experiments with a "Beehive" destructor, my committee desired me to go on, in spite of opposition and complaints from certain quarters, and Dr. Tidy (who was called in to advise the Richmond Vestry) strongly urged me to "fight it out." But legal proceedings were taken, as some one had seen a little smoke issuing from the top of the chimney, and a fine dust had been deposited in adjoining gardens. My committee then said that I must stop burning; that they could not have such a chimney in the place, or they would be swarmed with actions. I had placed early in the year 1885 a furnace in the destructor so as to burn the disagreeable fumes that previously escaped from the shaft, but after the determined opposition of the district (it being publicly stated that it should be closed at all costs) I abandoned the destructor, as I could not go on and risk my professional reputation under such circumstances. I must say that I have seen the Ealing chimney when I should not have considered it a good thing for the place; and though Mr. Jones may not have had complaints at Ealing, I certainly had at Richmond. I consider the construction of the Beehive faulty in many respects. The way in which the material is thrown into the furnace is a great mistake. Whether it was that I had more time that I could devote to superintending the destructor than other surveyors using the beehive I cannot say; but I found that, with thorough supervision, I could burn refuse at 10*d.* per ton. Still, at the same time, I should not now adopt the "Beehive." The Vestry decided to close the destructor at Richmond after it had been at work ten months. I will reserve any further remarks on the subject until I have more carefully perused Mr. Jones' paper.

Mr. Sadler: There are one or two points respecting which I wish for some information. One of these is the cost, which Mr. Jones has very properly put as one of the first considerations with town councils and local boards. In that, the cost of collection must necessarily be one of the principal items; but what I wish to arrive at most is the actual cost of working the destructor. I have had so many different estimates given to me, that I am really unable to say what the cost should be. The cost of collection must, of course, depend upon the local circumstances. The other point upon which I wish for information is, as to the single or double construction of the furnaces. In some places I have found them built back to back, and in others in a single row. It seems to me that, where there is a destructor of six or eight cells a great deal of power is lost by the single construction, because one side will be open to the air. In this matter we may say that heat is money, and the more heat we can retain, the more work the destructor will be able to do. I should also like to know what is the actual cost of a destructor, and the number of tons of refuse which can be consumed in a day in each furnace.

Mr. Andrews: I have come a long way to hear this discussion, which is on a subject in which my Board feel a deep interest. For some time my Board have been looking about for the best mode of dealing with the town refuse of Bournemouth. A committee of my Board visited nearly every town in England where a destructor was in use, and I accompanied the committee. Amongst other places we went to Richmond and Burnley, where we saw the "Beehive." The committee at once condemned the "Beehive" as they saw it at Richmond, but were more favourably impressed by the one at Burnley. When we returned to Bournemouth, it was decided to erect a destructor, and after a local board inquiry had been held, was put up at a total cost of 3,000*l.* This included 600*l.* for three acres of land, 900*l.* for the ironwork, and 1500*l.* for the brickwork and the chimney shaft. The chimney shaft is 137 feet in height, and alone cost about 500*l.* of the total amount. The destructor was only started last week, and all the fuel we have used to keep up the fires has simply been the coal refuse among the house ashes. The fires consume everything efficiently, and so far we have not had any complaint of any nuisance. As Mr. Jones puts it, everybody in the South complains of tall chimney shafts, and we have had to erect ours on the highest part of Bournemouth.

Mr. Warner (Nottingham): Several points have been raised in the course of this discussion, which I think should be answered. Mr. Meade has referred to destructors in various parts of the country, and wondered why more headway was not made with them in the South of England, than in other parts of the country. I attribute this to the condition of the refuse which has to be dealt with in the South, compared with that in Northern towns, and the means available for the disposal of the refuse. In London, especially, the refuse is collected from a population where the sewage is dealt with almost entirely by the water-carriage system. It does not, therefore, contain the matter mixed with the refuse which is found in many of the northern towns. That refuse is utilised in the making of bricks or roads. Having no fæcal matter mixed with it, there has been a ready means of getting rid of this refuse until lately. But now, brick-making having gone down, the cost to local boards of removing and getting rid of this refuse is greater than that of burning it in a destructor. This will have the effect of making the authorities of London and of Southern towns, see that the destructor is the best known mode of getting rid of house refuse. There is no difficulty in thus treating the refuse about London and in Southern towns; but there is some difficulty in thus dealing with the refuse of Midland and Northern towns. In West Bromwich, for instance, I believe there is a mixed system, the house refuse being emptied into middens connected with closets. Taken together this would burn, if mixed in anything like average proportions; but if, taken with a greater average of midden moisture, containing perhaps 90 per cent., the moisture would put almost too great a strain on the destructor. It would first have to be dried down, and then it would contain sufficient combustible matter to be effectually destroyed. I went down to Bournemouth with a friend, who had pointed out that the furnaces of the destructor there should be capable of raising a vast amount of heat—as much in fact as is obtained on board large steamships—but the material burnt was not equal in carbon to coal. In coal they got from 80 to 86 per cent. of carbon; but the best quality of refuse, such as has to be dealt with in Southern towns, only contains about 10 or 12 per cent. of carbon, which has to actually destroy or change the condition of the refuse in the furnace containing 90 per cent. of incombustible matter—to dry it in the first place, then to burn the dried material and fuse it into a hard clinker, which, in being formed, has to be subjected to the enormous temperature requisite to fuse iron. After this, you may feel perfectly sure there is nothing left in the product likely to be injurious to the public health. Sewage sludge, as it is taken from the tanks, contains about 93 per cent. of moisture, and after being allowed to stand, contains perhaps 40 per cent.; and this, mixed with house refuse containing perhaps 12 per cent. of moisture, has all to be burnt in one mass. The small amount of carbon in the house refuse would not be sufficient to carry off that volume of vapour, and the fumes given off during combustion would smell somewhat. This risk of nuisance has led Mr. Jones to put his wits together to see whether it can be avoided. Dr. Tidy, Dr. Hill, Mr. Hawksley, Mr. Codrington, Mr. J. T. Harrison, and other eminent men have inspected Mr. Jones' apparatus at Ealing, and have expressed a very high opinion of it. The heat given off by it is more than the germs in any vapour could support. It may appear at first sight that there was no invention, as furnaces to burn gases have been invented years ago; but you must bear in mind that previous inventors have not arranged for the requisite high temperature to be maintained by a small consumption of fuel. Of course, if more fuel has to be added, this increases the cost per ton of destroying the refuse, and raises the question whether it is worth while erecting a cremator. Mr. Jones has succeeded in so regulating his heat as to get a high temperature without the use of extra fuel. The vapours given off by destructors are to a great extent combustible vapours, containing as they do ingredients that are inflammable. Then the dust has been considered by many a great difficulty; but Mr. Jones has managed that this dust is thrown down in such a way as to prevent nuisance. The power generated by a destructor when at work is also worth consideration. It has been thought, if the refuse could be got rid of, it would be a good thing, and sufficient attention has not been given to the utilising of the heat generated as a motive power. I think this has been done to the greatest extent at Southampton, where the heat is passed through a special boiler, which gives sufficient power to eject the whole of the sewage sludge about a mile and a quarter. This power is equal to 30·6 horsepower, and as it is obtained from a four-cell destructor, is equal to about 7½ horsepower per cell. If the heat generated in destructors where it is necessary to have twenty to forty cells, the power thus to be obtained might be utilised in various other ways, and would help to reduce the cost of dealing with town refuse by destructors.

Mr. W. Dent: Although I do not hesitate to award the first place to Fryer's destructor for the perfection to which the apparatus has been brought, I think the remarks made by Mr. Jones respecting some other kinds of destructors are hardly correct. Mr. Jones has not inquired from me what we are doing at Nelson, or what it costs to work the destructor. Mr. Jones is wrong in saying it is a private speculation. It is designed to burn a special kind of refuse, and it is now regularly doing so at the very moderate cost of about 1*s.* 3*d.* per ton of refuse consumed. This is exclusive of working the cremator. My town contains a population of about 20,000 people, in a district where the most offensive refuse cannot be satisfactorily got rid of except by burning. So far from the destructor appearing not to have found much favour, the Local Board of Nelson has purchased it. Some slight alterations to the flues have been made in it; but I am not aware of any which would give Mr. Jones ground for complaint. The cost of working any cremator will of course be greatly influenced in every case by the price of fuel, and the quantity consumed in relation to the weight of refuse burnt. I should like to ask Mr. Jones what was the first cost of the cremator put up at Blackburn, in connection with Fryer's destructor, the cost of working it, and why it has been discontinued.

The President: As the time which we can devote to the discussion of this subject has expired, I would suggest that any one else who has any remarks to make should send them to the Secretary in writing, in time for Mr. Jones to reply to them, so that the whole may be included in the volume of our proceedings. What is wanted is practical information. We want the experience of every member of the Association who has dealt with this subject, so as to lay it before other members who have to advise their respective local boards on the question. No doubt the chief question which has occupied the attention of town councils and local boards is, that the difficulty of dealing with the refuse of towns is increasing. All are anxious to find out the best method of solving this difficulty, which increases in proportion to the growth of population. These difficulties are necessarily greater in some localities than they are in others; but the greatest difficulty which has hitherto had to be confronted is that of cost. On this point we have had some valuable information laid before us by a member of the Association, Mr. W. G. Laws, of Newcastle-on-Tyne, who has made it his business to ascertain the actual quantity of refuse collected, and the cost of dealing with it. Mr. Laws states that the average cost of removing refuse at Newcastle, estimating the quantity for the year at 124,010 tons, was 2*s.* 7½*d.* per ton. The amount received from the sale of manure was 148*l.* 17*s.* 5*d.*, from which 64*l.* had to be deducted for attendant expenses, leaving a nett balance of 84*l.* 17*s.* 5*d.* to be deducted from the cost of collection. With that deduction the total nett cost is 16,205*l.* If there were no other way of dealing with town refuse than burning it in destructors, then seventy-four cells would be required at Newcastle, at a nett cost, according to Mr. Laws, of 3358*l.*, or, including interest and redemption of capital, 6200*l.* per annum. These are facts which town councils, members of local boards, and members of this Association, want to know and get at. The practice hitherto has been to fill up pits with town refuse. In the course of time these places become valuable as building sites; but we, as sanitary engineers, cannot regard their use for such a purpose as a proper thing. Mr Jones has given us the cost of working his system at Ealing as 9*d.* per ton. I must say I think Mr. Jones has made a low estimate of it. Mr. Laws, including the interest on capital, puts the cost at 1*s.* per ton, and that seems to me a fair calculation. Thus at Newcastle the destruction of refuse costs 1*s.* per ton, in addition to the cost of cartage to the destructor. If the cost of carriage could be reduced, much would be done towards meeting the difficulty of total cost. The question whether they should erect destructors in the centre of populous localities was also involved. This difficulty Mr. Jones claims to have met with his fume cremator, if we can only impress that upon the town councils and local boards with which we are connected. I am not sure, however, that we have arrived at the best method yet. I have before me a report of a three days' inquiry before a Committee of the House of Commons; but the gentlemen called to give evidence were not able to satisfy the Committee to the extent of getting them to allow a destructor to be built at Kensington. Still, I am sure we owe a debt of gratitude to Mr. Jones for having contributed his interesting paper, and there is no doubt it will form a valuable addition to the proceedings of the Association. We also owe our thanks to the Mayor and Corporation of West Bromwich for the kind manner in which they have placed the Town Hall and Council Chamber at our service. We have been met and received to-day in a way we shall always be able to look back upon with pleasure.

The **Mayor of West Bromwich**: I am sure I can say, on behalf of my colleagues and myself, that we have had great pleasure in placing this building at your disposal; and that we are gratified that West Bromwich has been considered of sufficient importance for the Association to hold one of its district meetings here. I have listened with great attention and profit to the discussion which has taken place; and I shall take an early opportunity of reading Mr. Jones' paper, as West Bromwich, like many other towns with a growing population, has found a difficulty in dealing with the great problem of disposing of house refuse.

CORRESPONDENCE.

Mr. W. **Brooke**: Having carefully perused the valuable paper prepared by Mr. Jones, I cannot allow the statement published in his paper respecting the two Beehive destructors, lately in use here, to pass without some corrections, inasmuch as it might otherwise be somewhat misleading.

The two Beehives built at Richmond were the first erected out of the patentee's district, and were opened in August 1884, the writer then having been only two months the surveyor—the destructor having been recommended by a special committee of the vestry, after they had visited and inspected all the destructors then known in use in England previous to my appointment. The cost of erection of two hives, including chimney-shaft 90 feet high, was 443*l.* 4*s.* 6*d.*

Although at first the destructors consumed the quantity they were guaranteed to destroy, viz. 15 cwt. per hour for each hive, the frail construction of the destructors, together with the wrought-iron furnace-bars, which were destroyed with the great heat within twenty-two weeks, and were replaced by cast-iron bars, which were almost as good at the time of pulling down the destructors as when first fixed.

The mode of charging the destructor was faulty from the first, and the double furnace I found could be dispensed with.

The destructors had only been at work about two weeks, when complaints were made as to unburnt paper and other matter escaping from the chimney. A ½-inch mesh-iron grid was fixed in the chimney-shaft, which prevented this, but other complaints were then made as to fine ashes escaping. After about six weeks burning the destructors commenced to give great trouble on account of the frailty of their construction, and steps were taken to erect new destructors on a larger scale, or to rebuild them in a more substantial manner.

In January 1885, when preparing the plans for a new destructor (which were approved by the Dust Disposal Committee), the writer contemplated using one of the beehives as a coke furnace to consume the smoke from the furnaces proposed to be erected. These plans were abandoned on account of the continued opposition from certain ratepayers who stated they would have no dust destructors in the parish yard at all costs.

The writer, believing no destructor could be used without unfair opposition and prejudice, advised his committee (until the opposition quieted down) to repair the existing destructors, which suggestion was carried out in February and March 1885, at a cost of 141*l*. 14*s*. 11*d*., the same including all experiments made so as to prevent the alleged nuisance complained of by the adjoining residents previous to rebuilding.

To prevent the fine stuff escaping from the chimney shaft, the writer caused baffle plates to be fixed at the base of the chimney, and also a water chamber with water always passing over a weir so as to catch the heavy particles in the smoke, and which was found to answer the purpose very well; but after this, complaints were made as to the smell from the smoke. Having erected hot-plates for the drying of granite siftings used in making tar asphalte, over the flue from one of the destructors, and finding when the destructor was at work that the smoke was hardly perceptible, it was evident that the hot-plates caused the smoke to be partly consumed. I erected therefore in April 1885, a coke furnace which entirely consumed the whole of the smoke from one destructor, it being nearly impossible a hundred yards distant from the chimney to know if the destructor was burning even by throwing large pieces of tar asphalte into the furnace.

The writer is of opinion that most of the opposition encountered was merely sentimental; seeing the chimney shaft alone was a great bone of contention with many of the residents, it being the only large one in the district, and it was mainly on account of the solicitors engaged in the disputes, who seemed anxious to get the destructors closed, that the Vestry gave orders for it to be discontinued.

The committee, after the alterations had been made, were of

REFUSE SCREENED ONLY A PORTION OF THIS TIME.

s or.	Gross total cost of Disposal.	Gross cost of disposal per ton.	Credit.			Net actual cost of disposal of refuse.	Net actu cost per ton.
			Breeze sold.	Fine stuff sold.	Total.		
d.	£ s. d.	Pence.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	pence.
4	6 5 0	11·1	0 6 0	0 9 0	0 15 0	5 10 0	9·7

PLATES, &C. WERE FIXED.

Cost after delivery.			Total actual cost of disposal of refuse.	Actual cost of disposal per ton.
ing.	Tools.	Repairs to Destructor.		
d.	£ s. d.	£ s. d.	£ s. d.	pence.
6	0 5 0	0 7 3	5 18 1	11

S USED. REFUSE NOT SIFTED.

.	Breeze for Furnace.	Total actual cost of disposal of refuse.	Actual cost of disposal per ton.
	£ s. d.	£ s. d.	pence.
	0 10 0	4 3 1	16·6

to pay from 2s. 9d. to 3s. 3d. per cubic yard. The ashes are used

EEKS.

	Credit.			Net Expenditure.	Net cost of disposal per ton, allowing for value of clinkers.
	e sold.	Clinker used by Vestry.	Total.		
Au	s. d.	1260 yards used at 2s. 6d.	£ s. d.	£ s. d. 342 17 0	pence.
Ju	0 0	£157 10 0	166 10 0	166 10 0 176 10 0	10

WALTER BROOKE, A.M.I.C.E.,
TOWN SURVEYOR.

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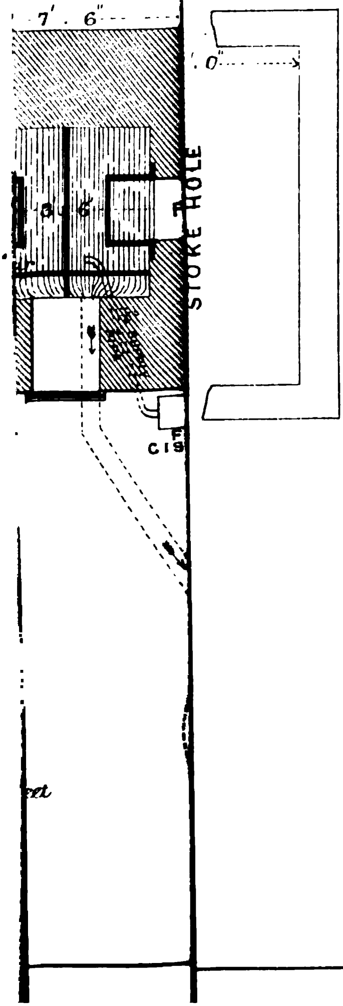

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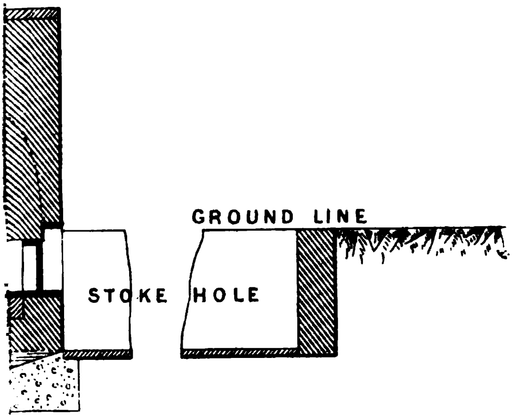


opinion that the actions then pending against the Vestry should be fought out, and they were, I believe, so advised in March by many experts, but the complainant having said he would stay his action upon payment of costs, the solicitor strongly advised the vestry (against the wishes of the writer) to close the destructors, and they were accordingly closed on the 18th June 1885, having been in use forty-two weeks.

The writer is strongly of opinion that the destructors after re-building would have destroyed about half of the town refuse at a cost of about 1*s.* 5*d.* per ton, as shown by table A, from which it would be seen that between the first week in March to the middle of June the destructors were constantly burning for sixty-three days without any cost for repairs.

Table A shows the costs during the three different periods the destructors were in use, viz., the period working with double furnaces as recommended by the patentee, when the cost of destroying the refuse, including sifting, was about 10*d.* per ton; the period after the grids and baffle plates were fixed, and which considerably lessened the draught, when cost of sifting and destroying was 11*d.* per ton; the period after the furnaces were re-built in a more substantial manner with grids, baffle plates, and smoke consuming furnace (when the refuse was not screened) when the actual cost for destroying the refuse was 1*s.* 5½*d.* per ton.

Taking the whole period from the time the destructors were first started until the closing of them the average cost (by allowing for the value of clinker) was 10*d.* per ton on the refuse delivered. If no value is allowed for the clinker, it would be 1*s.* 7*d.* per ton.

In arriving at the cost for the whole period I have allowed what would be the annual charge for repayment of principle and interest on the actual cost of the destructor, viz., 585*l.* at 4 per cent., allowing for the whole to be repaid in ten years.

The actual cost of destroying refuse by the Beehive destructor as experienced at Richmond, bears favourable comparison with the cost of destroying by other destructors elsewhere, although I am of opinion that Fryer's destructor is far superior to the Beehive, as the destructor as originally built was very faulty in construction, which no doubt accounts for the failures experienced with it elsewhere.

The accompanying drawings show how the grid, baffle plates, water basin, and smoke consumer were constructed in the destructor as used here, being taken from actual measurements before the destructors were pulled down, and the same as they were in use for about three months.

Mr. **Lacey** writes that he approves of the principle of burning ashes and house-refuse in the destructor, and utilising the heat generated thereby, but he disapproves of burning sludge in it. He has often noticed a disagreeable smell from the chimney-shaft of the Ealing destructor, and suggested that it might be advisable to increase the size or alter the form of the cremator, so that the gases might occupy a greater time in passing through it, and he holds that with a sufficiently large fume cremator, and increased facilities for freeing the flues from dust the destructor would serve the purposes for which it was invented, and he is about to advise his Board to adopt the destructor, utilising its heat for pumping purposes, and making up the balance of power by the cremator.

Mr. Lacey greatly objects to the mixing sewage sludge with the house refuse, so allowing a partially decomposed mass to accumulate for weeks for the purpose of being put through the destructor. As an instance, if it were proposed to adopt this method for dealing with the London sludge, assuming the population of the Metropolitan district at 3,500,000, and the quantity of sludge at only 1 ton per thousand per day, and it took six weeks for it to become sufficiently consolidated to remove to the destructors, there would be a continued accumulation of some 147,000 tons of sludge mixed with perhaps an equal quantity of house refuse.

According to details of quantity and cost of the disposal of sludge and house refuse, all the Ealing sludge is not burnt. The quantity of mixed sludge and ashes actually burnt is stated to be 3945 tons, as follows:—

Ashes mixed with sludge	1089 (viz. ⅓ of 3267)
Sludge produced from population	4421
Total mixed	5510
Deduct quantity carted away by market gardeners	1565
Quantity of mixed sludge actually burnt ..	3945

with which the remaining 2178 (two-thirds of total) tons of dry ashes are burnt. It is therefore, after all, only reasonable to suppose that, if it were necessary to burn the 1565 tons of mixed sludge given to market gardeners, it would require a proportionate amount of dry ashes, viz. 864 tons, to effect its proper combustion. This is the more important when it is considered that not nine-tenths of the sludge of the district is dealt with at the southern works, although all the ashes of the district are.

Again, referring to the details of cost, he does not consider it fair to deduct the entire saving of fuel, viz. 171*l.* 12*s.*, as the working of the atmospheric ejector and mortar mill are certainly for the disposal of the sludge and refuse clinker. There is also no account of lime introduced into the sewage sludge before being ejected into the tanks; cost of water for hydraulic lift used for lifting sludge to the top of the destructor; or cost of carting the breeze, which is at least 1*s.* per chaldron, to the Brentford works.

Mr. G. R. **STRACHAN**: The principle of disposing of the dry household refuse of towns by fire is emerging from its experimental to its practical state. Since its inception it has been modified, and it will have to be further modified and adapted to the actual conditions of the problem, before it can be regarded as satisfactory in its application. Some of the destructors are the occasion of annoyance arising from inherent defects and from careless management. I regard the principle of destroying dust by fire as a most valuable one, and as one worth much effort and study to apply it in the fullest manner to the practical problem. As surveyors, we have this question in our special charge. We are the men who will erect destructors, we will have charge of them in our daily work, we will find out their lack of efficiency, and it will be by our suggestions and experiments that remedies for defects will be found. Our Association should play a leading part in the solution of this question. If every one who had sewage disposal works under his care had regarded himself as an experimenter, whose aim was to find the solution of a scientific problem, and had given the world the benefit of his mistakes as well as of his successes, much public and private money would have been saved, and the solution of that problem would to-day have been common knowledge. We are now starting on the development of this principle, and as we are public men experimenting with public money, we should avoid these hindrances. Every destructor erected should contain the latest developments of the principle. If every surveyor places his experience frankly and fully at the disposal of the Association this end will be attained, and we will have made our Association the means of solving a sanitary and scientific problem. Holding these views, I regret that Mr. Jones has not corrected a statement on the question made by him at Ealing, in 1884, and which is printed on page 203, Vol. X., of our 'Proceedings'—"On the question of nuisance arising I must distinctly say there is nothing for any nuisance to arise from in the use of a destructor." It was true when he said it, but does not the fact of his having patented a "fume cremator" to be added to the destructor, show that he has found reason from further experience to modify this statement. Mr. Jones, in his paper, has not dealt with that annoyance from destructors which Mr. Hewson graphically described as "salting and peppering" the district with fine dust. Mr. Hewson frankly states that it occurs at Leeds, which has its destructors in a thickly populated neighbourhood. It may be that the Ealing destructor, being in a comparatively open country, has not given Mr. Jones the opportunity of ascertaining that it exists. There can be no doubt that a destructor causes annoyance, however. In March or April of this year, Mr. H. L. W. Lawson, M.P., wrote to the Whitechapel Board of Works as follows: "My attention has been drawn to the nuisance caused by the destructor recently built by you in the immediate vicinity of my property in Wentworth Street. Having erected a block of industrial dwellings in that street, specially adapted for the use of the poorer classes, I learn from my tenants that the cleanliness of the place is most prejudicially affected by volumes of dust, &c., discharged from the destructor." About the same time the Rev. Mr. Barnett wrote to them: "When the destructor was started I refused to take any part in opposing your plan, holding it to be my duty to support you in a reform. . . . Now, however, after some months' experience, I do make a formal complaint that the chimney deposits a large amount of light, partially consumed paper ash. This falls so thickly as to cover the ground, and in one case to stop a gutter." These complaints bear their own evidence of genuineness. The destructor was in full work in October, 1886, when I visited it, so that six months had elapsed before these gentlemen complained. In like manner the City destructor has caused annoyance. The Rev. H. Jephson applied at the Southwark Police Court in July last for advice as to remedying the nuisance caused by the nauseating effluvia, cinders, and other refuse which escaped from the shaft. This defect is due to the heightening of the shafts of destructors. At first they were 120 feet high; then, as better combustion was needed, they were raised to 150 feet; then to 180 feet for the like reason. The dust as it is delivered to the furnace contains some completely burned ash in the form of dust that cannot be destroyed by fire. As the dust slides down the sloping hearth the fierce draught catches this ash and hurls it through the shaft. This is a defect due to the present method of creating a draught. There must be a fierce draught to consume the dust: that draught is obtained by a tall shaft, but the taller the shaft and the fiercer the draught, the more the dust-distributing efficiency is increased. It would thus appear that the method of a tall shaft to increase the draught is erroneous. The "fume cremator" will not cure this defect, for the mineral dust will pass untouched through it, having previously been through a fire of at least equal temperature. I am a sceptic as to the value of the solution of the sludge difficulty by burning it. The principle laid down that "the dust of a town is sufficient to burn the sludge of a town," is one of those general statements which can, in my opinion, be disproved, for the author asserts that sludge can be burned by itself. The cost of these destructors is, in my opinion, excessive. No one can object to the patentees recouping themselves for the time and capital sunk in their invention, but I am sure that unless they are prepared to accept a price at once reasonable and remunerative, one of two things will happen: (1) the destructor will be less frequently adopted, or (2) endeavours will be made to devise a new form of furnace. The inventors should recognise the fact that the principle and details of their destructors are being amended by public money. Every destructor which is erected reveals some defect, which is avoided in the next. It is therefore reasonable to ask that experience gained by the expenditure of public money be not charged for to the public at too high a price.

Mr. Jones: The first gentleman who has taken up the discussion is Mr. Lemon, and following his remarks I can find but little to reply to. Like myself, he had a nuisance to deal with, "and travelled all over England to find a mode of getting rid of the nuisance." And what conclusion did he arrive at? "The most effectual mode was to erect a furnace which Mr. Jones called a 'muffle furnace.'" Mr. Lemon does not agree with me in burning the sludge, does not think it the right thing to do, and concludes with the following remarks: "However, he gets rid of a nuisance, and that is saying something for him"; it is unnecessary for me to say more. I had a nuisance to get rid of, a terrible nuisance, both in a sanitary and a monetary point of view, and I have by a simple means, effectually got rid of it. Mr. De

Courcy Meade says, "I cannot but think that if the Metropolitan vestries were to see a few of the destructors at work, their system for the disposal of refuse would be soon abandoned." I do not doubt but that this will be the natural outcome of the discussions now taking place, for Battersea and Hampstead have, since the paper was written, opened destructors with fume cremators attached, and I am happy to say they are both working well. I refer only to the Metropolitan vestries; there are others in other parts of the country, which during the last six months have been opened, and which I am, from inquiries made, justified in saying are working in every way satisfactorily. With respect to the remarks of Mr. Walter Brooke, bearing in mind my experience with the Beehive destructor, I cannot in any way criticise the remarks made. The question relative to the same is one which Mr. Brooke has answered himself, and I see no reason to alter the opinion I formed with respect to same. The questions raised by Mr. Sadler of Cheltenham, are important, but at the same time, the reply to them must depend very much upon the mode in which they are treated. The experience which I have gained during the months which have elapsed since the discussion was first started justifies me in saying that the expenses I have set forth in my paper as applied to the Ealing destructor are maximum expenses for working a destructor of that size, and I think it may be taken that two men a day and one man at night are sufficient to work in the most thorough and complete way a six-cell destructor with cremator attached. In one case, to which I will refer at the conclusion of my remarks, this was not so. Upon the point of single or double construction, to which Mr. Sadler refers, in my opinion for four or six cells the single construction is the best, but beyond six cells, say eight to twelve, I think they should be built back to back; it will be found that, in the majority of cases, in the single destructor the difficulty anticipated by Mr. Sadler does not take place, as the back wall is generally protected by the overhead platform. With respect to the absolute cost of the destructor, this, to some extent, as I have endeavoured to show in my paper, must be dependent upon the cost of material and labour in the place where the destructor is built. I have, however, generally given it as my opinion that 300*l.* per cell should include all the expenses necessary both for the destructor and cremator. As I have previously stated, the cost of the shaft at Ealing is 700*l.*, being 143 feet in height. The one at Bournemouth is 137 feet high, and cost 500*l*. I am pleased to hear the remarks made by Mr. Andrews, of Bournemouth. It must be evident that that which would satisfy the fashionable seaside resort of Bournemouth ought to be satisfactory to any town in England; and the testimony which Mr. Andrews has borne, after some months' experience of the work of the destructor and cremator, is, they have no reason to complain, but that it is highly satisfactory to every one concerned. The interesting remarks made by Mr. Warner upon the question of destructor, are valuable, inasmuch as they are the result of many years' experience, and I cannot but feel gratified at the testimony which Mr. Warner has borne to the work which the destructor has done. I will now refer to the question Mr. Dent has put, as to why the cremator was discontinued working in Blackburn. This cremator was not erected under my supervision, and I found, on visiting Blackburn, that it was not well designed, and to use the words of an eminent Government inspector, the cremator was "badly placed, and there were unfortunate throttlings of the draughts." The complaint made, however, was against the cost, for it appears from the evidence of the inspector, already referred to, and from the 'Proceedings' of the Council itself, that "the nuisance complained of was, however, abated." The great expense of working was mainly caused by using coke at 5*s*. 10*d*. a ton, instead of breeze at a cost of 1*s*. 6*d*. or 2*s*. per chaldron. This I proved to the committee by having the ashes in the dust yard screened, when it was shown by the pyrometer that the heat could be maintained with such material at from 1200° to 1300° Fahr.

The Members visited the extensive Iron Foundries of Messrs. John & Samuel Roberts, Swan Village, West Bromwich. These works cover a large area, and employ about 500 *men in the various operations of pattern-making, moulding, core-making, fitting, turning, &c. The process of manufacturing large gas and water pipes of* 48*-inch diameter and downwards was shown, and the filtering shops, where turned and bored socket-pipes were being faced by special machinery of novel construction, were also inspected. On leaving these Works the Members proceeded to the Piercy Blue Brick, Tile, and Terra-cotta Works of Mr. Joseph Hamblet. On the way examples were seen of the effect of mining subsidences, causing houses, buildings, and tall chimneys to be cracked, pulled to pieces, and out of plumb. On reaching Mr. Hamblet's Works, the marl-hole was first visited, where the* *marl and rock is got by blasting, and charges were exploded in view of the Members. The marl and rock is conveyed from the quarry by means of a tramway to the mills where it is mixed in proper proportions. This marl is suitable for both red and blue bricks; the blue is the hardest and best, and is simply caused by increased and longer continued heat in burning. The rock and marl is tipped into the mills and passed through the rolls. On the bricks, &c., leaving the machines they are taken to drying-rooms, where they are sufficiently dried by heated flues under the floors before removal to the presses. The presses are Hamblet's Patent, and are worked by friction discs, computed to give a strain of* 120 *tons on each brick, and any pattern can be pressed on the face of them. The bricks finished by this process stand a crushing strain of* 1064 *tons per square foot, as tested by Kircaldy. Copings for walls are made both by means of wood moulds, and stock kinds by steam press. The kilns in which the goods are burnt are Scotch kilns lined throughout with fire-bricks, but the great heat required in burning blue bricks soon destroys them. It requires about a fortnight to fill, burn, and empty a kiln, and eight days and nights are required for burning only. The Members also inspected the manufacture of encaustic tiles of different designs, also the modelling of terra-cotta for several important works. They also saw the manufacture of ridge-tiles, and chimney-pots by machine, ensuring their being perfectly true. The burning of the encaustic tiles is done in pottery kilns, and the tiles placed in "saggars" before burning. Upwards of* 200 *horse-power is required in the mills.*

After the inspection the Members sat down to a substantial luncheon, kindy provided by Mr. Hamblet. The Members proceeded to Dartmouth Park, belonging to the Corporation, where a boating lake and open swimming bath was being constructed by the borough engineer, Mr. Eayrs. The park contains 65½ *acres, and the land was presented by Earl Dartmouth. It has been tastefully laid out in walks and drives, and being of an undulating character, having very extensive views of the surrounding country, it is the favourite resort of the "Black Country" inhabitants. It contains a lodge, conservatory, band-stand, refreshment room, shelters, observatory, drinking-fountain, and latrines, and has grounds laid out for cricket and football. The new boating-lake contains* 6 *acres with an island of nearly* ½ *an acre. The ground will be filled up and excavated as required to form the* *bottom of the lake, so as to have a depth of water safe in case of accidents, being 2 feet on one side and gradually sloping to 4 feet on the other, a box puddle will be run round the embankment, a landing stage will be provided, also a boat-house, with accommodation for thirty boats, and also an office. The boat-house and office is in half-timbered work, the upper portion being filled with rough cast, and surmounted by a weather-vane. The open swimming bath has an area of ½ an acre, with a depth of* 6 *feet* 6 *ins. at one end and* 2 *feet at the other. Diving-boards are provided and indicators showing the depth. The bath is enclosed by a high boarded fence, so as to secure privacy, and a dressing shed and latrines are provided for bathers. The cost of the work is* 3000*l. After driving round the park the Members returned to the Town Hall, when the discussion on Mr. Jones' paper, on 'Refuse Destructors and their Results up to the Present Time,' was continued.*

DISTRICT MEETING AT LUTON.

October 29th, 1887.

Held in the Council Chamber, Town Hall, Luton, by kind permission of the Mayor, Mr. Councillor Blundell.

Mr. O. C. Robson, Surveyor to the Local Board, Willesden, was unanimously re-elected Hon. Secretary for the Home Counties district.

THE SEWAGE WORKS OF LUTON.

By W. H. LEETE, Borough Surveyor.

The town of Luton, situate at the southern extremity of Bedfordshire, is the chief centre of the straw hat and bonnet industry, having at the present time a population of about 30,500; its rateable value is 104,316*l.*; the municipal area comprises 2600 acres and it has about 30 miles of roads and streets.

Situated at the head of the Lea watershed, and above the intake of the New River Company, also the large lakes in the Hoo estate belonging to the Leigh family, the authorities have been, from the earliest development of the place until now, jealously watched, and greater precautions have been enforced and required from time to time to prevent pollution of the Lea and the lakes, as this paper sets forth. They have never failed to make increased provision for sanitary requirements, as the necessities caused by the growth of the town have demanded of them.

Luton derives its name from the river Lea, which rises in the parish three miles above the town, at Leagrave Marsh. The stream is very small in its course through the town. Its original name was Lygea Byrig ("lygea" meaning a river in an open field, and "byrig" a town). In Doomsday survey it is called Loitoine; in the reign of Henry VII., Lewton, and in that of Charles I., Lvton.

The Lea has of recent years, during the droughts, been almost dried up. About the year 1800 there were only five streets, and within three years of that date the first bridge was erected over the stream.

The original industry was malting, of which no fewer than sixty kilns were worked, also a few tanneries, and there were six water corn-mills on the stream. The straw plait industry was first introduced by a company of Lorraine plaiters, who left Scotland, owing to troublesome times in the reign of Mary, Queen of Scots. The trade has grown from small beginnings to the present extent of an annual turnover of 1,750,000*l*.

In 1821 the population was 2980, and the number of houses 586. Up to 1850 the town was without any system of drainage, other than open ditches and drains leading direct to the river. "The Public Health Act, 1848" was adopted by the town, and on August 12th, 1850, the first meeting of the Local Board was held, and from that time the town has steadily increased in population and in the improvement of its sanitary arrangements.

The growth of the town and increase of commerce brought with it grave difficulties, as the then owner of the Luton Hoo estate (Mr. J. S. Leigh) charged the Local Authority with the fouling of his lakes, and obtained an injunction to restrain the Authority from polluting the stream. As a result of this action plans were invited, and a scheme was decided upon in the year 1856, when 1½ acres of land between the Park Road and Windmill Road were purchased, upon which to erect outfall works, viz.:—

An engine and boiler-house with machinery, also receiving-tanks and filter-beds, were erected, and fitted up with sludge-lifting and lime-mixing apparatus for dealing with the sewage, in connection with which an intercepting sewer was constructed of about a mile in extent, measuring 42 inches by 30 inches, with a gradient of 1 in 600.

Sir Joseph Bazalgette was consulted as to route, levels, and method of construction of the sewer, and after completion, on an examination made by him, he reported on the unsoundness of the work, and suggested caulking and rendering in cement, which, if done, was very badly executed, as spring water, at certain seasons, in very large quantities found its way into the sewer. It is much to be regretted that Sir Joseph Bazalgette's recommendation to put in the sewer at a lower level was not carried out, it would then have been clear of the bed of the stream.

The town steadily grew from time to time, and new works were added; an undershot water-wheel driven by the effluent was fixed to work the liming gear, and a set of three plunger-pumps for lifting the sludge. Additional storage tanks were also dug, and a large excavation was made to receive the storm water.

The Local Authority in the year 1868 were again served with a notice, in conformity with an Act, chap. 154, dated 30th July, entitled "An Act to make better provision for the preservation and improvement of the river Lea and its tributaries, and for other purposes." As a result of this legislation, in which the then Local Board was represented by our late esteemed townsman, Mr. Evan Owen Williams, also Mr. Alderman Higgins and Mr. George Bailey, Clerk to the Board, and mainly by their efforts, the following clause was inserted:—

No. 101.—"Nothing in this Act shall operate or extend to prevent the Local Board of Health for the district of Luton, and the inhabitants of the town of Luton for the time being, from maintaining and continuing their present sewerage and drainage works, or from discharging into the said river Lea the sewage water or matter flowing from such sewers or drains after such sewage water or matter has been subjected to the process of purification known as Higgs' process, in pursuance of conditions enjoined upon them by the writ of injunction awarded against them by and out of the High Court of Chancery on the twelfth day of April, one thousand eight hundred and fifty-eight, in a suit wherein her Majesty's then Attorney-General, at the relation of John Shaw Leigh, Esquire, was informant, the said John Shaw Leigh being plaintiff, and the township of Luton Local Board of Health defendants; or some other process which from time to time may be in use, as the best then known practicable process for the purification of sewage to the satisfaction of her Majesty's Secretary of State for the Home Department. In case any difference shall arise thereon between the Conservancy Board and the said Local Board of Health, they shall, if required by the said Secretary of State, adopt such improved process accordingly, providing that the said Local Board of Health shall not increase the sectional area of their present sewerage and drainage works."

In order from time to time to meet the wishes of the Conservators, several processes were tried claiming to perfectly effect the precipitation of the matter held in solution, clarification and purification of the effluent, Whitbread's bisalcic phosphate with lime, and others, but all signally failed to produce a clear and satisfactory effluent, or to effect any improvement on the simple lime process. I may here observe that the sewage of Luton during a rainy season is very much diluted with subsoil and spring water, and is also continuously deeply coloured by dyes used for dyeing straw plaits.

Most of the vegetable dyes, when they come in contact with any of the mineral acids, form such strong liquid dyes that it is not possible to disintegrate the component parts, to be able to bring the liquid to a clear state, without incurring a very costly chemical treatment, and possible death to fish in the lakes near outfall. The same can be said respecting the strong aniline dyes now extensively used, which when they come in contact with strong acidulated mineral solutions, form liquids impossible to bring to a clear state by the ordinary means of precipitation.

The local plait-making industry has during the last six years declined until it has become almost obsolete, owing to the enormous importation of foreign plaits, alleged to be equal in quality to the local manufacture, and much cheaper. The plaiter has now to make up the foreign-made plait into hats or bonnets; this has had the effect of driving the villagers into the town, and creating a great demand for cottage property.

Finding that the clarification of the sewage could not be obtained either to the satisfaction of the owner of the Hoo Estate, the Lea Conservancy, the New River Company, or the Local Authority, by the use of chemicals and precipitation, the Authority, which had but recently emerged from a Local Board into the more dignified and larger representative body, viz., a Town Council, set about endeavouring to cope with the difficulty, and in 1878 plans were made by the writer, and an application to the Local Government Board for a loan of 10,000*l.* obtained for the following works, viz.:—

The purchase of mill and miller's water right, and the removal of this, the last water-mill on the stream, close to the outfall, lowering and straightening of river bed and its course, new road, sewers, outfall, and a bucket-wheel to raise the sewage of a district below the general discharge of the town sewer. Purchase of five acres of land adjacent to the tanks, levelling, terracing, and draining the whole, underdraining 1½ acres an average depth of 3 feet and 6 feet apart in peaty loam soil; the remaining 3½ acres of terraced chalk formation was drained 7 feet deep and 12 feet apart, all discharging into the stream above flood-water level. Levelling and ridging also 17½ acres of leasehold ground. Laying 15-inch and 12-inch rising main with requisite valves, and making carriers and conduits. Building engine and boiler house, and putting down a horizontal 20 horse-power condensing engine and 25-inch pump, calculated to lift 1½ million gallons in 12 hours.

The machinery was erected by Messrs. Withinshaw, of Birmingham, from their own design, and has done good service. This machinery, when repaired, will be a very useful reserve power for the lower levels.

The making of sewers, road, bridge, and river was let by contract, the remainder of the work was performed by the Corporation's own workmen. The whole of the work was completed within the estimate.

The experience of the benefits arising from the effect of first using chemicals, precipitating the solids and pumping the partially clarified water on to the deep-drained area, was only satisfactory so long as the fine chalk passed away with the effluent during the first year or two. The ridging of the surface was each year alternately worked, thus giving the water each season a new and clean filter; yet, notwithstanding the depth of drains and the solid chalk it had to pass through, the effluent water passed away highly coloured.

In order to more fully test the value of deep drains, I put some in the leasehold land, and sealed with puddled clay the top joints of pipes in order to compel the water to pass through the solid walls and thence up into bottom of pipe; the result of this trial was equally disappointing, the colour being still as decided. Under these circumstances we were compelled to use the 17½ acres of land without intermission, causing it to be continuously flooded in the hollows, not daring to lay another outlet to the Lea as was at first contemplated. Natural earth had and did dispose of some 800,000 gallons of sewage six days in every week. Chemical treatment was again tried, viz., Hille's salts of magnesium and tar with lime, which was to be the cure of all our ills and shortcomings; the patentee had the works placed at his disposal for six months, only to fail more signally, leaving us in a filthy condition. Mr. John Hanson's black ash has also been tried, but was found to be quite ineffective, not in the least degree touching the colour. These circumstances and the insufficiency of our pumping plant to cope with the entire flow of twenty-four hours' sewage, and worse still, our very limited area of land, laid us open again to complaints from the old quarters.

The borough between 1876 and 1885 grew very rapidly, almost to the extent of one-third extra population.

The Council determined to look out for sufficient land at a distance from the river, to admit, if possible, of the sewage flowing by gravitation, but owing to the natural features of this part of the Lea valley, it was found impracticable; and as we should have had to have recourse to pumping under any circumstances, it was decided to look nearer home. For a long time we tried to obtain part of a small farm adjoining our leasehold land, but found the price, viz 250*l.* per acre, out of the question; fortunately, we were driven further afield.

The new farm comprises 71 acres, 1 rood, 27 poles at an average price of 128*l.* per acre. It is situate just outside and adjoining the borough boundary, and its extremity is fully a mile beyond the pumping station, its greatest height 184 feet.

The nature of the soil is as follows:—the foot of the hill has a good depth of excellent staple overlying the chalk, and at its lowest point is 11 feet above the springs; the hill-sides and upper ground have but a very shallow depth of staple, varying from 9 inches to 4 inches, and frequently on the south-eastern side the chalk crops through. The first layer of chalk is open and small, varying in depth from 2 to 5 feet, under which there is larger chalk lying at an angle of 50°, which was found somewhat loose but free from large fissures. Very few flint stones in the chalk were found in the excavations of tanks and rising main. The land served by the three carriers below the summit is close, being strong clay and rank stones, having frequent hard, marly chalk cones or heads cropping up near to surface. This portion is not good ground for the purpose of irrigation, and it is fortunately but a small portion of the whole.

The land is irrigated in the following manner:—

A 16-inch C. I. turned and bored rising main is laid from the pumping station, having a reflux valve close to the air vessel and Stone's gun-metal faced valves *en route* to serve every level as follows:—

				ft.		ft.	
1st	valve	commands	land adjacent to station	10	to	20	lift.
2nd	„	„	land between railways	..	..	42	„
3rd	„	„	1st conduit on new farm	..	..	61	„
4th	„	„	1st set of tanks on new farm		..	70	„
5th	„	„	3rd tank on new farm	..	..	116	„
6th	„	„	4th „ „	..	..	125	„
7th	„	„	5th conduit and 1st above tanks			136	„
8th	„	„	6th „ and 2nd „			145	„

This point is the end of 16-inch main and top of chalk land measuring in all 1541 yards, costing per yard including valves 21*s.* 10*d.*

							ft.	
9th	valve	commands	7th	conduit	and 3rd	above tanks	158	lift
10th	„	„	8th	„	and 4th	„	170	
11th	„	„	9th	„	and 5th	„	184	„

N.B. This point is the top of rising main and summit of farm. The length of the 12-inch main is 220 yards, costing 16*s.* 6*d.* per yard.

The valves are in each instance clear of the rising main the end of which is always open, being protected by large wrought-iron caps, allowing perfect freedom for the delivery of the fluid.

In order to have thorough control over the volume of sewage to be dealt with, I have constructed on the hill-side, at the 62 feet level, two tanks, and other two at the heights respectively of 116 feet and 125 feet. These are but simple earth excavations, the base of the new banks measuring from 35 feet to 50 feet; they were originally 12 feet high and 4 feet wide on top to allow for subsidence, the inside slope being faced with strong puddled clay starting a foot in the solid at the bottom, about 18 inches thick and following the batter of the slope to a height of 24 inches above high water, where it is only 12 inches thick, which has proved effectual in holding the water.

Disc valves are used for the outlets to carriers and sludge-beds, one small sludge-bed being provided for each tank, of similar construction to the tanks. The poorness of the land, however, will admit for a long time of the crude sewage being applied directly to the land without any interception of the solids. These tanks will hold 1,023,700 gallons, and may be filled twice in 24 hours. The tanks cannot get unduly filled, as a 12-inch overflow drain is provided to each. The amount of absorption through the bottom and slopes of embankment is very great, and when they were first filled, the whole of the sewage percolated through in 48 hours. The cost of these tanks, including valves, &c., amounted to 462*l.* or 9*s.* per thousand gallons. The average capacity of each tank is 255,937 gallons.

The conduits or carriers from the various levels, are simple earth cuts to a fall of 1 inch per chain, following the contour of the hill-sides; glazed block sluices are placed a chain apart, and in the smaller carriers land pipe drains are laid through the banks, 6 yards apart, for the distribution of the sewage over the ground by occasional clearing out these cuts, they are kept clean. The length of these carriers over the farm amounts to slightly over 3 miles, and cost at the rate of 8¾*d.* per yard.

An area of about 9 acres of land at the foot and side of the hill is laid out in a series of levels and ridged, so as to ensure the retention of the sewage and uniform distribution over the entire area, without any large accumulations at the foot of the hill. The cost of this class of work amounts to the sum of 16*l.* per acre.

The chief area of the farm is laid down with rye grass, for which we have had a good sale this year; it is the cheapest crop on a sewage farm. We have also about 16 acres of arable land, upon which we grow corn for our own horses.

With regard to cropping the sewage farm, our past experience has been very varied. Some years we have been able to show a fair profit, but last year's superabundant produce caused our crops to be almost given away, entailing a deficit.

The sewage as it enters the works passes through a series of screens, the first being hoist-screens worked by a hand crab in duplicate. These were recommended by Mr. Law, Engineer to Madame de Falbe, as preferable to the original design, viz., a fixed grating at an angle of 60 degrees; we have, however, found it necessary to supplement these hoists by putting fixed screens to each tank before passing the sewage to the pumps.

We have three old storage tanks, in which we can receive and hold if necessary, about 700,000 gallons, which are used to hold the night flow. The tanks are connected with a well 9 feet diameter, and 14 feet deep, in the new engine-house, into which the 18-inch suction-pipes of the new pumps are carried.

The boiler-power we have now is equal to 130 horse-power, viz., one old 30 horse-power Lancashire boiler, 26 feet by 6 feet 6 inches, and two new 50 horse-power boilers, 30 feet by 7 feet, steel plated, having Galloway tubes, and the most recent improvements. The new engines are 100 horse-power, coupled, horizontal, rotating, high-pressure condensing engines, fitted with Meyer's variable expansion slide-valves, and Porter's patent governors. The pumps are 19½ inches diameter, of the horizontal double-acting type, fitted with metallic bucket-rings and circular double-beat valves with guttapercha beats, stroke 3 feet, working at 16 revolutions per minute. The whole of the new plant is capable of raising 1½ million gallons of sewage per day of 12 hours, 200 feet high.

We have made a few tests of coal consumption, before the covering of the boilers and pipes was effected, and found the cost as follows, taking twenty days working on the various levels, viz.:

3 days on the 125 feet.
15 days „ 70 „
5 days „ 42 „
—
20
—

The average of coal used was 39 cwt. per day, say two tons. The average number of gallons pumped per day, as registered by the recorder, was 1,075,000, showing a cost of one farthing per thousand gallons, taking coal at 11*s.* per ton on the works. Taking the consumption of fuel for two days, pumping to the highest lift (184 feet), the coal used was 3 tons 17 cwt., and the volume of sewage lifted 1,210,000 gallons per day, costing seven-sixteenths of a penny per 1000 gallons. The coal used is Blackwell slack, supplied direct from the pit.

The whole of the new machinery has been designed and executed, I think in a very excellent and highly creditable manner, by Messrs. Hayward, Tyler, and Howards, of Whitecross Street, London, and Luton; the contract for the whole was 2760*l.*, which with a few items of extras will possibly bring up the amount in round figures to 3000*l.*

The result of the working from the 31st May, 1887, to the present time has been very satisfactory, and has placed the town of Luton in a position of independence, as regards the disposal of the entire sewage of Luton without an outlet to the river Lea, which it has never previously occupied.

Our dry-weather flow of sewage for 24 hours is 820,521 gallons: during the wet weather the flow is more than double.

Our old engines when put into repair will be equal to raising 800,000 gallons in 12 hours in addition to the new plant; we shall then have power to lift 2¼ million gallons in that time. The Town water-supply equals 750,000 gallons per day.

A few months ago we had two thousand or more cubic yards of sludge about the pumping station; but, thanks to the dry season and neighbouring farmers, it has all been removed, never more to jeopardise the health of the neighbourhood. The sludge is now daily pumped with sewage on to the new farm a mile distant from the town.

At the request of the Town Council, the whole of this work was designed and carried out by the writer of this paper, with the exception of the machinery, the design for which was the result of a competition.

The engine-house, boiler-house, shaft and other new buildings are not embellished architecturally, but are, we consider, sufficient for the purpose required; the cost of the whole amounted to 2173*l.* We have been able to keep within our estimate of 20,000*l.* and the result so far as we are able to judge at present is quite satisfactory.

The Association may have viewed more scientific work as regards the construction of the tanks and conduits, but we claim to have good reasons for not going to a larger outlay, owing to the distance of the farm from the town and river, particularly, as we are blessed with a splendid chalk base of a possible depth (as has been stated by geologists) of three hundred or more feet.

I am extremely pleased to have the honour of your visit here to-day, and certainly should not have presumed to invite you had not our esteemed President urged the advisability of the meeting of to-day.

DISCUSSION.

The **President**: We are, I am sure, very much obliged to Mr. Leete for the interesting paper which he has read to us; but I think it would be rather difficult for the members of the Association to enter into any discussion thereon till after they have seen the works. Perhaps, the Mayor, however, may like to say a few words on points not touched upon by Mr. Leete; and we may hear something too from the gentleman through whom, practically, Luton has been induced to carry out the works that have produced the present high state of efficiency in regard to sanitary affairs—a gentleman who may be looked on also as the High Police Commissioner of the Lea—I mean Major Flower. We all know that gentleman. He appears at almost every inquiry where works are to be carried out in the water-basin of the Lea. The purity of the Lea is of pre-eminent importance to the residents of London, and it is to Major Flower that the various towns on its banks have to look for some little mercies in getting time to carry out works such as we are about to see to-day. I believe that Major Flower will tell us that he is perfectly satisfied with what has been done by the Authorities of Luton. We shall see what a town may and can do when prompted, and in some measure compelled, by such gentlemen as Major Flower, to undertake sewerage works, and where it is so favourably situated, and has a sub-soil so suitable for a sewage farm that it can carry out to a perfect state the purification of the sewage of the town.

The MAYOR OF LUTON: Allow me to say, as the representative of our Corporation, that it affords us very great pleasure to welcome so distinguished a company to listen to the paper read, and to view the works with which more particularly it deals. In the presence of gentlemen skilled in all that pertains to sewage works, it would ill-become me to enter upon details; but I may say that from the first inception of this scheme success has attended the work. The purchase of the land and the various proposals incident to the enterprise, with all its intricate matters of detail, and everything connected with the scheme, seemed to favour us. After securing the land, the fact that we had a resident firm of engineers to compete with others for the production of the engines, pumps, &c., at the works, and that we had on the Council gentlemen of considerable experience in such work, especially the esteemed Chairman of the sewage works (Alderman Higgins) who since the year 1850 had had this whole matter under his notice, and had rendered very valuable service as a member of the Local Board of Health immediately after the adoption of the Act which entrusted us with the power of local government, all operated to secure the success of the undertaking. The providing of the requisite materials was also on favourable terms, the iron mains being procured when iron was at its lowest price. The works will best speak for themselves when inspected by the Association. From the first it has been the aim of the Council, while studying the strictest economy, to fulfil our obligations to the lady of the manor and the Conservators of the Lea, by whom we have been most carefully watched.

Major FLOWER (Engineer of the Lea Conservancy Board): It gives me very great pleasure to be here to-day to see so many men of practical knowledge at this place, which I call my pet town. It was in 1871 that I took charge of the Lea watershed, under the Lea Conservancy Act of 1868. By a certain special clause in that Act, obtained at some cost by the town of Luton, and referred to by Mr. Leete in his paper, the authorities retained the power to discharge their sewage into the Lea after treatment by the best known process. The same clause affects Hertford, Tottenham, and the Borough of West Ham. The latter town is supposed to bring its effluent up to the condition required of Luton, and it is the same at Hertford and Tottenham. After considerable experience—and I am sure that most of you will agree with me—I have come to the conclusion that land is the only absolute purifier of sewage-matter up to a point making it fit to discharge into a river out of which people draw their drinking-water. I have very great respect for many chemical processes, because there are many places where a sufficiently good result is obtained thereby. Nobody dreams of being able to do all that is reasonably required of the British ratepayer by chemical treatment, when the effluent is to go into a stream from which drinking-water is drawn. Chemical processes and adequate filtration, or by flowing over land will do in many places, but they will not meet the exceedingly complex circumstances which obtain in others. At Luton, for a time, chemical treatment, supplemented by filtration on a small area of land, was sufficient; but ultimately Luton sewage became so loaded with chemicals and dyeing refuse as to render it exceedingly difficult of treatment; and chemical processes, which in other towns might be sufficient, had no effect whatever on the sewage of Luton. I feel that I should be hardly doing my duty as an official if I did not say here how pleased those whom I have the honour to serve are with the honourable and thoroughly English way in which Luton has met the necessities of its position. My Board is exceedingly pleased, and I know that I am not going beyond my duty here in thanking you, Mr. Mayor, with Alderman Higgins, who has worked so hard in this matter, and other gentlemen connected with the borough, for the result, and I am satisfied that my friends here, the municipal surveyors and sanitary engineers, will be pleased to give their approval to it.

After visiting the works, the Members returned to the Town Hall, and the President called upon Mr. Ellice-Clark to continue the discussion.

Mr. Ellice-Clark: Mr. Gordon, in calling upon me to continue the discussion has made a great mistake; for I was only remarking to him this afternoon that although I have held office for twenty years as a municipal engineer, the question of the disposal of sewage in an inland town has never been reported on or treated by myself, and therefore I feel incompetent to criticise or to praise. But my position may have a few advantages, in so far that I am not prejudiced in favour of any particular method of sewage disposal. Certainly the works which we have seen to-day are to my mind exceedingly ingenious and well-designed, and, as far as can be seen at the present time, they do their duty most effectually. But I should be wrong if I did not, as we are asked to discuss matters fully and freely, convey to you the impression that is left on my mind after having seen your works. We saw a sewage farm, and we saw sewage tanks, but we did not see what people generally like to see, and usually see first, at sewage works, namely, the effluent. I was telling Mr. Gordon on the hill-side, that it reminded me very much of Constable, the great painter, when he produced one of his remarkable pictures. The standard of taste had always led the critics of those days to look for a brown tree in a picture, and none was considered perfect without it. The Suffolk artist produced a picture, but they looked in vain for a brown tree, and a critic said to him, "Very pretty, young man, very pretty; but where's your brown tree?" Now, I ask, "Where is the Luton effluent?" I am bound to say that I think in a few years' time if you cannot see it, some one will find it out for you. An arrangement very similar to this has come under my own observation in the county of Sussex, where the sewage of a small village is discharged in a valley of the chalk downs, very like where we have been to-day. A quantity of water lies in a large pool during the winter, half a mile from the sea. It is stopped by the railway embankment, and never reaches the sea, yet it forms a stream underground, and other people know what becomes of it; and, I believe, from what I have seen to day, that your works may go on for some time—for some years—possibly for this generation—but depend upon it, some day or other, you will have to deal with an effluent.

Mr. W. Santo Crimp: I am sorry, Mr. President, that you have called upon me to say anything in regard to this question, because I may say that I differ entirely from Mr. Clark when he says that some day or other Luton will have trouble with an effluent. I think that the finest thing in connection with a sewage farm is to have no drains and no effluent. The two banes of a sewage farm are subsoil drainage and an effluent, and at Luton you have neither; and I think the day is far distant when you will find necessity for either. If such a time comes, then your troubles will begin. Till then you may enjoy the advantages arising from a very excellent system indeed of sewage disposal.

Mr. C. Jones: I am very pleased to be present, and to have heard what has been said by Mr. Clark and Mr. Crimp. I think perhaps, they are both right, and probably both wrong. But, to touch upon the works, which I take to be the great thing to refer to, I must say that I have enjoyed exceedingly my visit to them. They convey to us a scheme well thought out, well manipulated, well carried to a finish; I remember being in a Hertfordshire town when there was talk of a drainage system, and the clerk of the Authority said he did not see the use of it, for there was a cesspool in his garden, which was there in his father's and his grandfather's time; for ninety years it had never been emptied, and there was nothing whatever in it. I said to him, "How about your neighbours down below, they must have the benefit of it." "Well," he said, "perhaps they do, but they seem to thrive very much on it." If in the chalk slope there be crevices through which any of the sewage may find its way to the stream, I am sure we shall all wish that to whomsoever it comes they may thrive upon it. It has been a great pleasure to me to see these works, for they are unique, and I think our Association may take some credit in regard to them, as your esteemed Surveyor has been one of its most regular and attentive members at the various meetings held since he joined us. In the 'Proceedings' published this year, and issued a fortnight ago, the engineer of one of the largest towns in England makes a note to this effect, that Town Councils knew little of the loss they sustained by their engineers and surveyors not belonging to this Association; and if he had his will he would distinctly insist on every municipal engineer belonging to it, for there he would get information which could only be obtained by the expenditure of large sums of money in fees to men who knew little or nothing about the physical characteristics of their districts. We can take credit to ourselves that your Surveyor has been with us, and has made use of his eyes. You all know the story of eyes and no eyes—one went through the streets and lanes and saw nothing, the other passing along saw a great deal. Your Surveyor has been with us, and what he has seen he has brought home with him and improved upon; because he has seen nothing exactly like your works, but he has produced and carried out a scheme adapted to your conditions, which is an honour to him and to you as the Town Council.

Mr. J. P. **Barber**: This is the first meeting of the Association that I have been able to attend; for, as a gentleman remarked just before the meeting commenced, I was one of the class whom the Association fought shy of, and kept out for years. I have had great pleasure in listening to the paper read by Mr. Leete. A large portion of my time when I was under articles, was spent about sewerage works. Many of the Local Board districts about Manchester were drained by the sanitary engineer under whom I had the honour to serve, and in that way I contrived to pick up some information and a good deal of experience; and I am glad that the surveyors or engineers of those Boards were not like the Surveyor of Luton. Either they could not or did not produce schemes for the drainage of their districts; but Luton has been fortunate in possessing a borough surveyor and engineer capable of designing a drainage scheme without having to call in any consulting engineer like the gentleman to whom I was articled, and being put to that expense. The system which we have seen to-day is, while unique, very successful. I was struck with the sewage farm itself—the nature of the soil and its position. It appears to me that Luton could not have secured a sewage farm in a more favourable situation. I have seen many, but I do not remember one so suitable—away from the town, having a natural fall, soil porous and open, and exposed freely to the action of air, sunshine, and wind, so that the soil is not likely to become clogged with sewage matter, as is experienced in many places. The soil will be almost self-cleaning under the action of the atmosphere, wind, and sun, and it must be almost impossible to have any smell from it. The land seems rather poor, so that there can be no difficulty in disposing of the sludge, for it can be placed on the surface and ploughed in, making the soil the richer. These were my thoughts as I passed over the farm, and the visit has afforded me a great amount of pleasure and information.

Mr. **Lewis Angell**: my words shall be very few, and those in commendation of the works we have seen to-day. The Mayor has said that Luton has been fortunate in every phase of its operations when carrying out this scheme, and I think the town and the authorities have been indeed fortunate throughout; for what we have seen to-day is I think the perfection of simplicity. "Unique" is an expressive description which has been used, and I think that I have never seen sewage got rid of so very easily and so cheaply. Luton is at the head of the river Lea, and I represent the district at the tail. We were the head and tail of the offending, but while Luton has now taken itself out of the category, we at West Ham have not being able to get out of the difficulty so easily. We are unfortunately condemned to chemicals. I congratulate you on having got rid of wretched chemicals, which are costly and unsatisfactory. But while Luton increased by thousands, West Ham increased by tens of thousands, and our position is a very remarkable and onerous one. I congratulate Mr. Leete on having in the inception of this scheme struck out such a very original course. He has been more fortunate than I was in a case elsewhere. In a Kentish town I proposed that the drainage should be carried to the chalk in a similar way, but it was influentially opposed. The Government Inspector feared the sewage must find its way through crevices in the chalk, and pass to the basin of the watershed, scientific evidence was given against it, and I had to abandon the scheme. In Luton you have not met such opposition. Mr. Ellice-Clark has significantly inquired, what becomes of the effluent? and thinks that it will by and by appear. But I don't think you need trouble. I have heard that the water about here is rather hard, and that the wells are not very far off. Well, possibly it may be found that there is a softening process going on, and the water will become as soft as can be desired. I am pleased to bear testimony to the great skill which your borough surveyor has displayed, and to congratulate Luton on having got rid of the great difficulty from which most towns are suffering. Fifteen or eighteen years ago I came here to see what you were doing, and found large tanks and a precipitation process in operation, Mr. Higgins being then Chairman of the Local Board, and I am very pleased to have repeated my visit under the very favourable circumstances of to-day.

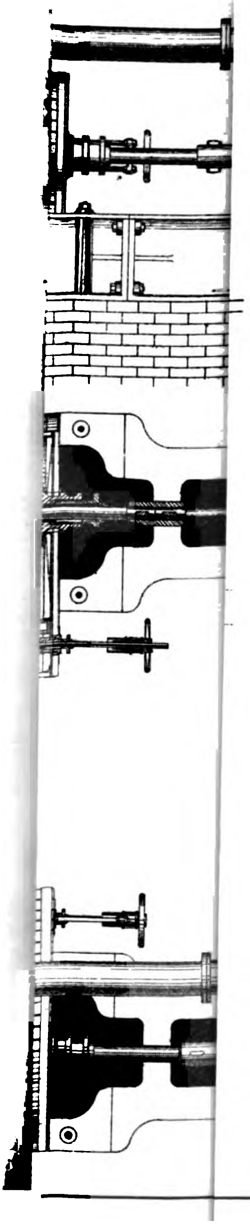
The President: Mr. Jones has told you he thinks that our Association may take credit for having something to do with the inception of these works, seeing that your surveyor has been a very attentive member; and I think that probably he will tell you that he has benefited to some extent through being a member and attending the Association meetings. But I take credit to myself for having pressed upon Mr. Leete this visit, in order that such unique works as these should not be lost to our Association, and the published proceedings which we issue annually. When I came here recently and saw these works, it occurred to me at once that there were here a set of works which we should have great difficulty in finding elsewhere, for their simplicity as well as uniqueness. On that account I pressed on Mr. Leete the usefulness of the Association holding a meeting here. I should have been very pleased to have seen a larger number present, especially of members from places of similar size, because I think they would have learned much from what has been done here by Mr. Leete. The simplicity of the works is very remarkable. It would be somewhat difficult for Mr. Leete to show the elaborateness of detail which we are accustomed to find in larger works, and on that account I think that his communication is exceedingly valuable to the Association, and to other towns similarly situated to Luton. There may not be many so favourably placed, in regard to the general conformation of the district and subsoil, for getting rid of their sewage, but still the works are suggestive and useful. So far back as 1858 Luton secured an undoubtedly valuable right not conferred by the Public Health Act, in being able to turn its sewage matter after chemical treatment into the Lea. At that time Higgs' treatment was thought to be the best purifying process by precipitation, although up to now no chemical system has been discovered which would produce a good effluent, such as ought to go into a river like the Lea from which water was drawn for the supply of London. You have had a most valuable right and might have fought it probably a little more than you have done; but, as has been said, Major Flower was constantly on the watch, and through ingenious members of the Council, and the industry of your Borough Surveyor, you have hit upon the best solution that there is to be found. Mr. Leete told us you endeavoured to devise a scheme which could be worked by gravitation lower down the valley, but he did not explain how it was that it could not be carried out. Of course, wherever an outfall can be obtained by gravitation it is much to be preferred. You then had a lime process, and I should have liked to hear the quantity per gallon used. Hille's process was tried, and he told us it failed as it has done elsewhere, and then you had Hanson's black ash, with the same disappointing results. You have gone through precisely the same course as nearly all other towns which have had chemical processes for a much longer period than Luton, and tell the same story. You cannot by chemical process purify sewage so as to render it fit to flow into a stream from which a water-supply is drawn, unless the stream is a very large one indeed in comparison to the volume of effluent to be put into it. Mr. Ellice-Clark expresses some fear of the effluent being found out. Probably he means that it may make its way into the Lea, and that wells sunk in the chalk lower down the valley may ultimately show some chemical traces of your sewage. On looking at the scheme, that idea would naturally arise; but I think under your circumstances it will only occur at a very remote period, and that the subsoil of chalk must become saturated to a very large extent before any impure water can be chemically traced in the Lea. Probably some twenty or thirty years hence there may be an effluent perceived, but even then the sewage will have passed through such a quantity of chalk that the impurity remaining will be infinitesimal, and never found in the Lea. I think, therefore, that you need not have much fear on that head. Still the quantity of land you have is phenomenally small, so that some day the contingency referred to may occur. You have in all 93 acres at Luton for a population of 30,000; whereas it is laid down as a general rule that you should have 1 acre for every 100. Under ordinary circumstances, therefore, you would have needed 300 acres. But discussion has explained your different position. In the nature of the soil with its base of chalk lies your salvation. I feel sure that Mr. Leete will tell you that he felt confidence in designing this scheme and recommending it to you from having come in contact with other surveyors belonging to this Association, and in visiting other works. I want to impress that on all our surveyors, and corporate authorities. I am glad that the Corporation of Luton have recognised the usefulness of our Association by assembling here in such numbers to meet us. I am perfectly certain that if the Town Councils and Local Boards throughout the kingdom would evince the same appreciation of its work they would reap immense benefit in the larger character of the works their Surveyors would be able to undertake, without having to call in consulting engineers. Surveyors would be better able to advise local authorities from the greater knowledge of sanitary matters which they would gain by being members of the Association. I congratulate Luton and its Corporation on having brought to a happy completion such unique and successful works. It is a pleasure to us to see that Mr. Leete's skilful services are valued by the Corporation, and I am sure that nothing which we have seen to-day or have said by way of criticism—and we do not meet simply to compliment each other—will in any way detract from the esteem and appreciation with which you regard your Borough Surveyor. As an Association we have very great pleasure in being here, and in helping, if we can help, such a gentleman as your Surveyor.

Mr. LEETE: Words fail me entirely to express my feelings, in returning thanks for the profusion of kind words which have been made use of in regard to the designing and carrying out of the scheme which the Town Council have done me the honour of entrusting to my care. When first asked to undertake the work I felt that it was a very great task; but by close observation and application to the work, coupled with the knowledge gained, as Mr. Jones and the President have said, by visiting various sewage works in the country, and attending the Association meetings, I have been established in the course which has been followed, and feel perfect confidence in its success. It is a very great satisfaction to me that gentlemen of the professional standing of those who have spoken to-day should have given such unqualified praise to a scheme devised and executed by one so humble as myself. I can only say that I have done all I could to make it a success, and I hope and believe it will work out so in the future. As to a gravitation scheme, we did not adopt one because we should have had to take the sewage a very considerable distance below the Luton Hoo Park at the foot of the town, nor could we find suitable ground, as it rises very suddenly from the stream, and would have involved pumping even if we had gone five or six miles away; moreover, we found soil better adapted for the purpose nearer home. Out there in the valley the soil was of close clay, and less absorbent than the land which has been obtained. I am much obliged to the gentlemen who have spoken. For myself, I am more accustomed to working than speaking, and I hope you will pardon my feeble response. I am grateful to the members of the Association who have thought it worth while to inspect the Luton Sewage Works, and also for the attendance of so many of the Town Council to listen to their observations.

The Members and visitors drove in carriages to the Pumping Station, where they inspected the engines and pumps, settling-tanks screens and other arrangements. They then proceeded to the Sewage

UMPINC

F LUT ton.



Farm, where they highly commended the irrigation scheme for its simplicity and effectiveness. A visit was also made to the Waterworks to inspect the pumping engines, and on the return-journey the visitors were shown over the Manufactory of Messrs. Carruthers Brothers, where the various processes in the manufacture of straw and felt bonnets and hats were shown. The programme included a visit to the Dye Works of Messrs. Lye and Sons, but time did not permit of this being done. On returning to the Town Hall, the Members and Visitors were hospitably entertained at luncheon by the Mayor. Among other toasts the Mayor proposed "The Association of Municipal and Sanitary Engineers and Surveyors," expressing his high sense of the value of the organisation.

Mr. Gordon, in response, pointed out that its object was to promote amongst the Members the highest skill and greatest experience, so that they might carry out in the best way the important works entrusted to their charge without having to call in so often consulting engineers. Examinations had been instituted by the Association, which were conducted by examiners of the highest qualifications, and the certificates granted were guarantees of the competency of their holders. He acknowledged the appreciation of the Association shown by Corporations and Local Boards, and especially recognised the attention and hospitality shown them at Luton.

Particulars of the PUMPING MACHINERY furnished by Messrs. Hayward Tyler and Co. for the Corporation of the Town of LUTON, Bedfordshire, for raising SEWAGE WATER, thus:

Steam Cylinder	33 in.	diam.	36 in. stroke.
Sewage Pumps	19½ in.	„	36 in. „
Air Pumps	12 in.	„	36 in. „
Fly Wheel	12 ft.	„	18 in. width.
Rising Main	18 in.	„	2000 yards.
Suction	18 in.	„	in all 215 ft. lift.
Air Vessel	36 in.	„	× 15 ft. long.
Vacuum Vessel	16 in.	„	× 10 ft. „

Engines fitted with steam jacketed cylinders, mahogany lagging and brass bands, Porter's governors, Meyer's expansion gear, Harding's speed counter, steel crank shaft, steel connecting rods, steel straps, gibs and cotters, steel crank pins and cross head pins, steel piston rods and cotters, steel piston rings, steam cylinders lined with hard cast-iron.

Sewage Pumps fitted with hard cast-iron liners, C. I. buckets and hand brass bucket rings, C. I. double beat valves and seats, steel pump bucket rods and cotters, and with Nipperman's air-charging apparatus.

Air-Pump Condenser, fitted with hard gun-metal liners, buckets, and rings, steel bucket rods, sheathed with hard brass, rubber disc valves, gun-metal valve seats, gun-metal guards and nuts.

Vacuum, 25 to 27 in.

Speed of Engines—minimum 14, maximum 24 revolutions per minute.

Steam Pressure—minimum 30 lbs., maximum 70 lbs. per square in.

Various lifts for engine and pumps are 30, 55, 85, 140, 160, 180, 200, and 215 feet.

Approximate total weight less rising main, 100 tons.

DISTRICT MEETING AT MAIDSTONE.

March 17, 1888.

Held in the Council Chamber, Town Hall, Maidstone.

Mr. J. Gordon, *President, in the Chair.*

The Mayor (R. Waterman, Esq.) opened the proceedings by cordially welcoming the Association to Maidstone.

The President having suitably replied, Mr. O. C. Robson was re-elected Honorary Secretary for the Home Counties District.

The following paper was then read and discussed.

A REVIEW OF THE SANITARY AND OTHER IMPROVEMENTS IN THE BOROUGH OF MAIDSTONE DURING THE LAST TEN YEARS.

By FRANCIS C. J. MAY, Assoc. M. Inst. C.E.,
Borough Surveyor.

I am going a little out of the beaten track of the papers usually prepared for these Meetings by first recounting in a short and concise way a few of the historical facts connected with the borough of Maidstone in early times. Through them I shall lead up to the period which the paper is more particularly to describe. I believe that as these facts are of general interest they will not be considered out of place in that which is intended to be in other respects a thoroughly practical paper, and therefore I trust they will not be unacceptable to the Association. They will be confined principally to those features of the condition of the borough in ancient times which in some way or other are allied to the various important works carried out during the last decade.

BRIDGES.

Before the year 1871 there was but one bridge over the river Medway within the borough boundary. The first is said to have been constructed of timber. It was replaced in the fourteenth century by a stone bridge, 11 feet wide only between the parapets. Subsequently it was widened to 19 feet, but the date of this work is uncertain. In the year 1808 the width was again increased to nearly 27 feet, and the waterway was confined within five arches instead of seven as before. This bridge, in its turn, was superseded by the present handsome structure in the years 1879–80.

CHARTERS.

The first charter of incorporation was granted by Edward VI., and is dated July 4, 1548. There have been five several charters granted since, the last being dated June 17, 1747.

BYE-LAW.

Some of the bye-laws passed by the Town Council in Elizabeth's reign appear to us very amusing, but one at least might be very useful even in these days: it decreed that every young man "that liveth idly in the town" was to pay 6*d.* (equal to 10*s.* at the present time) to the Corporation for every day "he should be found idle and not using his art"; and if on conviction the money be not forthcoming, he was "to be imprisoned by the Mayor until he should reform himself." The same bye-law applied to "unmarried women under the age of forty years who were out of service." This, I think, may be considered a veritable model bye-law.

SANITARY CONDITION, 1572 to 1770.

The sanitary condition of the borough in 1572 may be gathered from the following description:* "At one time a surgeon and his family occupied the ground floor of a moderately sized house, another family the second floor, while a tailor and his wife lived in the upper storey. The poor inhabitants, to eke out a subsistence, kept pigs, which were allowed to roam at large in the daytime. In High Street, Week Street, Gabriel's Hill, and Bullock Lane there were deep foul gutters into which the pigs turned with avidity, and among the garbage and other refuse deposited therein found a ready means of appeasing their hunger." This state of things continued till nearly 1770. Under such conditions the inhabitants were exposed in an aggravated degree to the ravages of the worst forms of contagious diseases. The plague frequently visited Maidstone, and it suffered from numerous outbreaks of small-pox.

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* See History of Maidstone, by J. M. Russell, p. 223.

River Medway.

The traffic of the river Medway has always been a great benefit to Maidstone and the neighbourhood, but before the water was "penned" up the movement of vessels depended upon the state of the tide. In 1628, the first Act of Parliament was passed for improving the condition of the river. A second Act was passed by the Parliament of 1661–4, giving power to erect locks on the Medway, and to deepen it and construct a towing-path or horseway. Other Acts have been passed since for similar purposes. The Mayor in former times was the conservator of the river, but its management is now vested by Acts of Parliament in two companies. The Upper Navigation Company has jurisdiction above, and the Lower Navigation Company below, Maidstone. That eminent engineer, Sir William Cubitt, on being consulted upon some proposed alterations, spoke of the canalising of the Medway as a very fine piece of inland navigation engineering. The jurisdiction of the two companies extends from Tonbridge to the Thames at Sheerness, a distance of fifty-four miles.

Street Paving.

In the last decade of the eighteenth century the inhabitants undertook to pave the town. A contemporary writer called the condition of the streets "*scandalous.*" A committee was appointed in 1790 to obtain an estimate of the cost of the proposed improvement, and on January 17, 1791, the Mayor convened a meeting to hear and take into consideration the report of the committee. The cost of paving the principal streets with Kentish rag and Yorkshire stones, carrying drains through them and fixing up lamps, was estimated at 9000*l.*, and the interest thereon, together with the outlay for watchmen, the lighting of the lamps and the repair of the pavements, would, it was reported, amount to 750*l.* a year. To meet this expenditure it was proposed to levy a rate of 1*s.* 6*d.* in the pound on all householders, half to be paid by the landlord and half by the tenant. These propositions were embodied in the Maidstone Paving Bill, which was introduced into Parliament, and received the royal assent June 1791. "Commissioners of Pavements" were appointed to carry out the provisions of the Act, who continued to exercise their functions till 1866, when their duties were transferred to the Mayor and Corporation as the authority to carry out the Public Health Act, 1858.

WATER SUPPLY.

In Elizabeth's reign the inhabitants obtained their chief supply of water from an excellent and copious spring at Rocky Hill, which was conveyed in pipes across the Medway to conduits in High Street. In 1819 the Commissioners of Pavements increased the supply, made larger reservoirs, and laid down new pipes, transmitting 30,000 gallons daily to seventeen public conduits.

TOWN HALL.

The Town Hall was used for the County Assizes as well as the Borough Sessions; and the gaol in King Street also served the same double purpose, but being found inadequate and unsuitable for these purposes, a county gaol was commenced in 1812 and built at a cost of 191,000*l.* In 1827 the Assize Court in front of the new prison was completed at a cost of 40,000*l.*, and opened for county business. The borough trials are still held at the Town Hall.

GAS.

Gas was introduced into Maidstone in 1821 by a Mr. Gosling, who in 1823 sold his works to several of the inhabitants, who formed the Maidstone Gas Company.

LUNATIC ASYLUM.

In 1832 a county lunatic asylum was built at Barming Heath, within the borough boundary, for 168 patients. It has from time to time been enlarged, so that now it has accommodation for about 1500 patients.

PUBLIC BATHS.

In 1851 public baths were built by the Corporation at a cost of 6000*l.*, under the provisions of the Public Baths and Wash-houses Act.

THE CHARLES MUSEUM.

In 1855 Mr. Charles, of Chillington House, bequeathed to the town his collection of antiquities, and some of his books and pictures, with a request that they might be permanently preserved and known as "The Charles Museum." The Corporation gratefully received the gift, and at a ratepayers' meeting the Public Libraries Act, 1855, was adopted. Chillington House was purchased by the town for the exhibition of the collection, and the museum was opened in January 1858. This formed the nucleus of what is now one of the largest, most valuable and interesting museums in the provinces, principally due to the gifts of Mr. Julius Lucius Brenchley, a native of Maidstone, who also presented the very picturesque public gardens adjoining the mansion to the Corporation in 1872.

CEMETERY.

In 1858 a Burial Board was established, who purchased twenty acres of land about one mile south of the town, and converted the plot into one of the prettiest and best-kept cemeteries of the kingdom. All the graveyards within the borough were then closed, and this work may be considered as one of the first of the many sanitary improvements which have been carried out.

WATER SUPPLY BY COMPANY.

In 1860 the Maidstone Waterworks Company was founded, and acquired an Act of Parliament to supply the town with water from a number of springs within a distance of two miles from the pumping station near Farleigh Bridge, about two miles westward from the town. At this time, with the exception of the water supplied to the public conduits free, the inhabitants drew their water from wells, which in many cases were in dangerous proximity to the house cesspool, and most of them during recent years have had to be closed by reason of their polluted condition.

TOVIL BRIDGE.

In 1871, at a cost of 900*l.*, a light iron bridge for foot passengers was constructed over the Medway, opposite Tovil, a point about three-quarters of a mile higher up the river than the old bridge. This gave easy communication to the Tovil and Fant districts situate on the opposite sides of the river. The work cost but little, as the bridge was purchased secondhand of the authorities at Birkenhead.

High-level Bridge.

In 1872 a bridge for foot-passengers was constructed over the Medway in conjunction with the high-level bridge of the London, Chatham, and Dover Railway Company, about three-quarters of a mile below the old bridge, at a cost of 1600*l.* This provided easy and quick communication between the north-eastern and north-western districts of the town.

Maidstone New Bridge.

In 1874 the old bridge was reported to be in an unsafe condition. It was also generally acknowledged that it was totally inadequate to the increased and ever-increasing traffic, and that the time had arrived for the construction of a more commodious bridge. This is the first of the great improvements completed within the period to which my paper more particularly refers. Sir Jos. Bazalgette, C.E., was consulted, and acting upon instructions, designed the present handsome bridge. So great an undertaking naturally provoked much discussion. There was a divided opinion as to the relative merits of iron and stone as the materials of which the bridge should be formed. Sir Jos. Bazalgette said he had no predilection in favour of stone, but, after giving the subject his most careful consideration, advised that the bridge be built of stone, for the following reasons:—

1. A stone bridge of three arches is *cheaper* than an iron bridge of one span.
2. A stone bridge is stronger.
3. A stone bridge is more durable.
4. A stone bridge requires no expenditure for its maintenance.
5. A stone bridge of three arches gives a greater waterway.
6. A stone bridge in his opinion is more handsome.
7. A stone bridge is more in harmony with the surroundings, more particularly the old Parish Church, the College, and the Archiepiscopal Palace.

I think I may say with confidence the public are now quite satisfied that the Authority acted wisely in adopting Sir Jos. Bazalgette's design in stone.

The first pile of the new bridge was driven on the 24th October 1877, and the bridge was opened for traffic, August 6, 1879, by the Mayor, Alderman Ellis, at the present time chairman of our Drainage Committee. The bridge is formed of three arches, giving a clear waterway of 149 feet, or 32 feet more than the old bridge. It is 40 feet wide between the parapets, and is divided into a carriageway of 24 feet, and two foot pavements, each 8 feet wide. The structure is of Cornish granite, the spandrils and parapets being of Kentish rag stone, with granite pedestals, mouldings, string courses and coping. The carriageway is granite macadam, the foot pavements granite slabs seven inches thick. Mr. H. Law was the engineer in charge, and Mr. Ventris, now of the Strand Board of Works, was the resident engineer. The work was carried out by the late Mr. Webster. The cost, including land and buildings purchased, compensation paid in order to improve the approaches, law charges, &c., 59,468*l.* Of this sum, 24,000*l.* was subscribed by the Rochester Bridge Wardens, and 35,468*l.* was borrowed, for 60 years, on town bonds, at 4 per cent.

In the excavations some old timbers were taken from the bed of the river, which it was surmised formed part of the original wooden structure, and in the demolition of the masonry of the oldest portion of the stone bridge, a silver coin of Edward III. was found, and was regarded as a proof of the foregoing statements as to its antiquity.

SEWAGE WORKS.

The houses were, as a rule, drained into cesspools, by which the soil was completely riddled and polluted, as they had increased in number with the increase of the population, and by the lapse of time had become most foul and pestilential. The Pavement Commissioners sought to minimise the evil by allowing some of the drainage to be connected with their storm-water drains which discharged into the pen of the Medway, but this in course of time created a serious nuisance in the river. The sanitary condition of the town was therefore the subject of great complaints in many quarters, and it was felt that an efficient and comprehensive system of drainage could not longer be delayed; therefore in 1875 the Corporation, acting by the Council as the Urban Authority under the Public Health Act, 1875, determined to provide a sewerage system for the town.

Mr. Bailey-Denton, Mr. Baldwin Latham, and Mr. Lewis Angell (our respected first President and father of this Association), were each consulted upon the question, with the result that Mr. Angell's scheme was adopted. Messrs. Neave & Sons were the contractors. The first tender was accepted in 1877, the last in 1880, and the work was completed in 1881. The cost was:—

	£
Sewers, manholes, &c.	43,996
Outfall works	9,000
Land (7 acres)	1,822
Compensation, law and engineers' charges, &c.	5,000
	£59,818

As far as possible the separate system was adopted. The original scheme comprised 15½ miles of sewage drains, 6½ miles of surface drainage, independently of 4½ miles of existing drainage, which was utilized principally for surface drainage. The town has considerably increased since this system was completed, and new sewers have been constructed to the extent of about 4 miles. New surface drains have also been constructed, and others are in contemplation to the extent of about two miles.

We now have but very few complaints of smells emanating from the sewer ventilators in the surface of the streets. The system of sewers has been cut up into sections. As far as possible, each length of sewer or district section has been made to ventilate itself by the introduction of light iron flaps attached to the end of the sewer on the upper side of the manholes. By this means the sewer air is prevented to a great degree from passing from the lower to the higher levels, and so becomes almost equally distributed, instead of culminating at the highest points as it used to do. One point of great interest on this subject is the fact that the liquid refuse from the Tovil Straw Paper Mills was admitted to the sewers in 1884; it contains a very large quantity of caustic soda, used in the boilers in which the straw and esparto grass are prepared, and has a perfect deodorizing effect upon the sewage. As it traverses the whole length of the lower intercepting sewer, it has rendered us good service in the matter of smells. I am of opinion the foulness of our sewers, such as there is, is mainly attributable to the foul condition of our house drains, many of which are but very imperfectly flushed, as the Authority has not yet seen its way clear to compel a supply of water to be laid on to every closet, and until this is done, I am afraid I shall be unable to report our system as perfect. All our sewage flows by gravitation to the Outfall Works at Allington, about one mile north of the high-level bridge on the west side of the Medway. As the town is divided by the river, the sewage of the east side is conveyed to the west side by a siphon laid six feet below the bed of the river, a little north of the high-level bridge. The outfall sewer to the works is of concrete 3 feet in diameter. The outfall sewer leading from the works to the tideway of the Medway below Allington Lock, about one mile in length, is formed of concrete, egg-shaped, 5 feet by 4 feet, having a gradient of 1 in 1760, and forms a storage drain for the effluent from the tanks during the high tide.

On reaching the outfall works the sewage is first screened. The screens were originally lifted by hand, but I have now arranged a very simple plan for lifting them by machinery. The milk of lime was also originally arranged to flow direct into the tanks; but as I found it did not become sufficiently incorporated with the sewage to cause any great amount of precipitation, I removed the lime mixer to a building near the screen chamber. I also erected a grinding mill in the same building, preferring not to slake the lime before putting it into the mixer. I now add the milk of lime to the sewage at the rate of one ton per 1,000,000 gallons at the screen chamber, and I find that during its flow to the tanks, a distance of about 85 yards, it becomes much more thoroughly incorporated with the sewage, and so a greater degree of precipitation is promoted. There are but two precipitation tanks, each 150 feet long, 27 feet wide, 3 feet deep, giving a capacity of 75,937 gallons. The system of treatment is that of precipitation by lime only, the effluent, as before stated, passing by the outfall sewer to the tidal part of the Medway. As the land was the site of an old quarry, there were large holes into which it was thought the liquid sludge might be pumped for an indefinite period, that the water would drain from it into the soil naturally, or could be assisted by artificial drainage if necessary. This tentative and crude system was considered all that was necessary for the moment, as some time would elapse before all the house connections could be made, and the delay would give time to ascertain what was absolutely to be done and how best to deal with the sewage. We continued this system as long as we could. Our natural holes were at last filled with wet sludge, and by embankments, &c., they had been increased so as to enable them to hold as much as possible; the ground at last became sewage sodden, and percolation into the soil became stopped.

In December 1885, we came to quite a dead-lock through the banks giving out and allowing a large quantity of the sludge to flow like a stream of lava down the slopes of the wood direct into the Medway. It then became necessary to reconsider the whole question of sewage treatment. I suggested various ways to overcome our difficulties, and it was ultimately decided to continue the system of precipitation by lime, or any other better agent, should one be discovered, and to deal with the wet sludge by pressing, hoping to dispose of the pressed sludge to farmers.

The situation of our outfall works is peculiar. We have no access to it but by the river—the king's highway. The whole of the land planted with wood on the river front was a sloping bank almost to the edge of the river. When the works were constructed, the bank was excavated to a considerable depth below the water level for the formation of the tanks, and the ground was found to be so very treacherous that it was not possible to build the tanks as was first intended.

Before I could enlarge the works it was necessary to level a considerable portion of the land above the tanks. Fortunately we had a favourable opportunity for doing this during the winter of 1885–6, under the auspices of the Labour Relief Fund, which was started for the benefit of the unemployed. In 1886 my plans for the necessary buildings and machinery were approved at an estimated cost of 2200*l.*, which sum was to be borrowed. The usual inquiry was held, the plans approved by the Local Government Board, and the loan granted for thirty years. The buildings and machinery were erected and opened for work on January 3rd, 1887.

The buildings consist of press-house, boiler-house, coal and lime stores, lime elevating shed, and sand store. The machinery consists of two 3-feet 6-inch Drake-Muirhead sludge filter presses and pumping engine; one 25 horse-power Lancashire boiler; one donkey-pump, for feeding the boiler; one 7 horse-power engine to drive lime-elevating and sludge-agitating apparatus; one water tank; and one C. I. sludge reservoir, 12 feet by 12 feet by 6 feet deep, holding 5000 gallons.

The advantages claimed for the Drake-Muirhead presses are: 1st. Simplicity and economy of working by direct-acting pumps, instead of compressed air. 2nd. Reduction of the annual cost of working both in wear and tear of machinery, and in the renewal of the filtering material by the abolition of the usual cloths. 3rd. Greater rapidity of filtering, whereby cakes may be turned out in half-an-hour, working with a pressure of 80 to 100 lbs. per square inch.

As I have had numerous inquiries about these presses, and as our experience of upwards of a twelvemonth's working has been eminently satisfactory, perhaps a detailed description of them may be acceptable to you. They mainly consist of flanged cast-iron rings or frames, alternating with plain wrought-iron discs. These discs are covered on both sides with confibre, specially prepared for the purpose. It does not decay rapidly even in sewage, and indeed seems to stand better when continually damp than when dry, or alternately wet and dry. The form of construction is the result of numerous experiments which were carried out by the makers before the Corporation adopted the presses. The mats are attached to the discs in such a manner that they do not need any attention till the material is worn out. In our case the material has lasted upwards of twelve months, during which time the mats were never removed from the discs. This avoids the expense incurred in the frequent removal of the usual cloths for washing and repairing, the only real expense being the cost of removing the material when entirely worn out, which for presses like ours of 30 chambers each 3 feet internal diameter, costs 10*l.* per press per annum. I ought to mention that although the mats themselves form a sufficient filtering medium, they would eventually become choked up if used alone, and to counteract this tendency, it is advisable to use some kind of sand on the surface of the mats, and further, by so doing the cakes leave the mats very freely when the press is opened. Each press is capable of turning out 11 tons per day of 12 hours. Our presses have been working since the 3rd of January, 1887. We have turned out on the average about 45 tons pressed sludge per week, which is all we have had to deal with. At the present time we give away the pressed sludge. We are at no cost beyond the pressing, as it is taken away just as we empty it from the press trolleys. We hope to realise something for it after having ascertained its manurial value by actual use. Dr. Voelcker has stated its value at from 12*s.* to 15*s.* per ton. Copies of his analyses will be found at the end of this paper.

Two schemes have been suggested by a Maidstone gentleman for manipulating the pressed sludge so as to make it a valuable commercial commodity. They are not yet sufficiently matured to enable me to give you any details of them, but I may be able to do so at a future meeting.

PUMPS.

The presses are supplied with sludge by means of a direct-acting pumping engine. This engine pumps the sludge direct from the sludge storage tank into the presses, without the intervention of compressed air, thus constituting a very simple arrangement, and obviating the use of receivers or *monte-jus*, with their attendant inconveniences, and loss of time and waste of power. Our engine is of the horizontal duplex type, i.e. the piston of one actuates the slide valve of the other, and the plungers make a sufficient pause at the end of each stroke to permit the pump valves to close without concussion. These valves are specially designed to overcome the difficulties hitherto experienced in pumping sewage sludge. That this object has been accomplished in our case will be readily understood when I tell you that although they are fitted with movable covers to give ready access to the valves, yet it has not once been necessary to take off a single cover during the whole time they have been working. The pumps are of the plunger or ram type, which have the advantage over piston pumps, that the packing is outside and easily get-at-able, an important matter where gritty sludge has to be pumped.

Since all the house connections have been made, and the system extended to deal with the increase of the population, the tanks have proved to be of insufficient capacity to admit of a proper degree of precipitation. The average daily flow of sewage in dry weather has been ascertained to be about 900,000 gallons. On a moderately wet day it has been ascertained to be nearly 1,900,000, so I estimate that in continual wet weather it cannot be less than 3,000,000 gallons. These facts have led me to urge strongly upon the Authority the necessity of completing a perfect system of surface water drains as soon as possible. The two existing precipitating tanks are of course worked alternately, i.e. three days each. As each has a capacity of only 75,937 gallons, it is obviously impossible to obtain a clear effluent. The outfall is within the jurisdiction of a neighbouring rural sanitary authority, who have complained of the unsatisfactory quality of the effluent. I have therefore been instructed to prepare a scheme which will ensure a satisfactory effluent at the least possible cost. I prepared a scheme and submitted it to the Drainage Committee on the 15th February last. It is still under the consideration of the committee, but I have their permission to exhibit the plan and explain the scheme to you, as I think there may be some points of interest therein to you, and I should like to hear any remarks you may be pleased to make thereon. The chief points to be kept in mind are three:

1st. That more perfect precipitation is needed.

2nd. That the resultant sludge must be conveyed back to the presses.

3rd. That the whole of the additions must be arranged so that the existing buildings and plant may be utilised with but little alteration.

These points render it compulsory to lift the sewage. There is also a great advantage to be gained by lifting; it will enable me to construct the tanks above the river level, and to reduce the depth of excavation. This is of exceptional importance owing to the peculiarly treacherous character and situation of the land.

I propose to erect a new set of tanks for the day flow, and to utilise the old tanks for the night flow, which will be let out in the morning and lifted with the morning flow.

There are various available ways of lifting the sewage, such as ordinary reciprocating pumps, centrifugal pumps, chain pumps, and elevating wheels. After giving due consideration to these various methods, I am of opinion that the elevating wheels offer the greatest advantages, taking all things into consideration—viz. for simplicity and cheapness so far as concerns working expenses and the annual wear and tear.

The proposed elevating wheels would be of 27 feet diameter, and are each calculated to lift the sewage a height of 18 feet, from which it will flow to the new tanks by gravitation. The power required to drive each wheel will not exceed six-horse nominal. To provide this, and power for other adjoining machinery, two 7-horsepower horizontal engines will be fixed between the wheels, as shown on the lowest floor of the new engine-house, to be supplied with steam from the boiler-house. Each wheel will have thirty-six buckets, and revolving at the rate of five revolutions per minute, will lift 66,000 gallons per hour or 1,584,000 gallons per day of twenty-four hours.

Of the engines just mentioned one will be new, the second will be removed from the press-house where a larger one will be required, as will be explained later on. On the same floor as these engines there will also be fixed two lime-mixing machines, also driven by these engines, from whence the milk of lime will flow to the sewage to become mixed and well incorporated with the sewage in the process of lifting.

The second floor of the engine-house, which will be on a level with the land, is arranged as a lime store, in which will be placed a grinding mill, also worked by the engines underneath, and from which the lime-mixers will be filled by hoppers.

Each wheel, engine, and other machine is capable of doing the whole day's duty separately in dry weather, and when coupled together, to do all the extra work in wet weather. In the case also of repairs being needed, the sewage system, by this arrangement of duplicate machinery, need never be at a standstill, as is now the case very frequently.

The sewage, when treated with lime and lifted by the wheel, will flow into an open trough or channel, in which there will be bafflers and a fixed screen, fitted with an automatic scraper or rake, on an endless chain driven by the before-mentioned engines. By these means the lime and the sewage will become well mixed, the screen will always be kept clean, and the rake will deliver the solid substances into a trolley provided for the purpose. The rake will traverse the screen very slowly, but the speed will be capable of adjustment according to circumstances.

The limed sewage will flow along a channel between two rows of ten tanks partly on our own land, but the greater part in Mr. Styles' meadow adjoining. A gate will be placed in the channel in a line with the end of each pair of tanks, and there will be a gate from the channel to each tank. By this arrangement the flow of sewage may be arrested or regulated so that each tank, or each set of tanks, will be filled in rotation or otherwise, as may be necessary or convenient.

Each tank will be provided with an outlet valve and pipe for the effluent water, which will be drawn off from the top by means of floating arms, and will be conducted forwards by a drain to the existing outfall sewer.

There will also be an outlet sluice valve and pipe for the precipitated sludge, which will pass into a drain, and by gravitation flow backwards to the sludge reservoir under the engine-house.

Each tank is 40 feet long, 30 feet wide, and 5 feet below the inlet. Its capacity is 37,500 gallons, therefore twenty tanks give a total capacity of 750,000 gallons. Assuming that they are kept working sixteen hours per day, and are filled and emptied four times, allowing the sewage three hours to rest, and one hour for filling and drawing off and sweeping out the sludge, this will give a total capacity of 3,000,000 gallons per day.

The effluent, as before mentioned, being conveyed to the outfall sewer, requires no further treatment. The sludge, on the contrary, having flowed to the sludge reservoir, where the supernatant water is drawn off by means of a floating arm, has to be pumped up to the mixing tank, *en route* to the presses. Itis estimated that the quantity of sludge will be quite doubled, and you will readily understand that this part of the work must be done regularly, therefore a suitable set of sludge pumps is required. I propose to put a set of duplex sludge pumps in the old engine-house in the place of the existing pump, worked by steam direct from the large boilers. The increase in the quantity of sludge will necessitate the erection of a third press and pump in the press-room. This arrangement will take away all the work of the old portable engine except driving the rope. I therefore propose to alter the line of the rope, and make the engine in the press-room drive it and the lime elevating and agitating machinery.

As the existing 7-horsepower engine is too small to do the additional work required of it, and is the exact size required for driving an elevating wheel, I propose to transfer it to that duty, and to erect an 8-horsepower engine in its place. The same engine will also work the proposed hauling gear, by which the full trucks of sludge will be drawn from under the presses, instead of by manual labour as at present.

The alterations in the lime-elevating shed, for adding lime to the sludge before pressing, will effect a saving of lime, and render the cakes more uniform in quality, by applying it in the form of milk of lime, instead of a dry state as is now done.

You will, I think, further readily understand that although our present boiler is quite equal to provide all the steam required for the increase in machinery, yet it would be very unwise to depend upon one boiler. I therefore consider it necessary to put in another Lancashire boiler in the place already provided for it, say of 20-horsepower. As the boilers hold 5000 gallons each, it is necessary to provide another water tank. I have therefore arranged for one to be put up in the wood, above the existing one, 12 feet by 12 feet by 6 feet, to hold 5000 gallons. It will be filled by the donkey pumps before mentioned, erected in the position of the existing penstock chambers, near the old engine-house.

The contemplated alterations will lead to an increase in the consumption of coal and lime, and in the produce of pressed sludge. Each of these commodities must be taken in or sent out of store by barges, and each from the same level. I therefore propose to erect a light iron girder bridge across the tanks to carry a tramway. At the end of the bridge I shall fix the crane, now erected, near the dock, converting it into a steam crane, by which the lime and coal will be hauled from the barges and run to their destination. A shoot will also be formed at the end of the bridge, so that the pressed sludge may be brought from the store, tipped into the shoot, and thereby easily conveyed into the barge for removal.

The coal store will be formed by one end of the lime shed, and by a concrete wall bounding the high bank opposite the press-room, and covered with a plain galvanised iron roof.

An office in rear of the boiler-house, and a workshop adjoining the sand store, &c., will complete all the alterations and additions here.

The additional work will necessitate an increase in the working staff, and it will be obligatory that other men than the foreman should live on the premises. I therefore propose to build two workmen's cottages.

The working staff should, I think, be as follows:—

One general foreman.
One stoker.
Two press men.
One man, sludge pumping, liming, &c.
One attending to wheels, liming apparatus, &c.
Two tank men.

Being an increase of three men, i. e. the general foreman and the two tank men.

The annual cost of maintenance will be raised from 759*l.*, as at present, to 1048*l.*

The estimate of the cost of the proposed works amounts to 8443*l.* 2*s.* 6*d.*, exclusive of the land, as to which it has occurred to me to suggest that perhaps an exchange might be made of some of our high land in the wood for the low land in the meadow. The quantity of land required will not exceed two acres.

This description has, I think, exhausted all the chief points in the alterations and additions proposed, without going into minute details.

HOUSE REFUSE.

The removal of house refuse is done by contract. The town is divided into two districts as nearly equal as possible, and each contractor is paid 260*l.*, making a total of 520*l.* per annum. The refuse is carted to depôts on the outskirts of the town, and is disposed of principally to farmers.

STREET SCAVENGING, ETC.

We keep eight horses of our own to do the work of scavenging, watering and road repairs, but we have to hire extra horses during the winter months, according to the state of the weather.

STREET WATERING.

Odam's system of street watering by jets has been well tried in Maidstone, but was not a success and so has been abandoned. Watering by hose and reel has also been tried and proved a failure. We are using two-wheeled water-carts holding 220 gallons each. Believing them to be more economical, I have advocated the use of four-wheeled vans instead of carts, and I hope to be able to have some this season. I saw Willacy's patent cart working at Leicester last summer, but formed an opinion that it is unsuitable for narrow streets.

ROAD REPAIRS.

Our roads are mainly made up and repaired with local stones, Kentish rag, and surface picked or pit flints. Granite is used in all the principal streets where it is necessary to avoid the nuisance of frequent repairs and the rapid accumulation of dust or mud. It is also used on some of the principal thoroughfares leading to and from the town, where the traffic is heavy or the situation or subsoil is wet. In the year 1884 we borrowed 4000*l.* to convert the carriageways of the principal streets from rag macadam to granite macadam. The usual inquiry was held, and a loan was granted for four years. Mr. John Thornhill Harrison, C.B., held the inquiry, and after going thoroughly into the question and walking through the town, expressed the opinion that it was a very wise step. We advertised for samples and prices of the different kinds of granite, which were all thoroughly examined and tested, and an Elvan stone from Cornwall, called Penlee Elvan, was selected. I am of opinion that its wear will justify our choice. It was delivered here at 11*s.* per ton machine broken; but as I prefer hand-broken stone, I have this winter had it delivered in spalls at 8*s.* 8*d.* per ton, and I get it broken by hand for 2*s.* per ton. Kentish rag is one of the oldest and one of the very best of building stones. There are several large quarries in the neighbourhood, which form one of the staple industries of Maidstone. It is a very useful stone for road metal, and is largely used on roads of moderate traffic, and where the subsoil is dry. Its use is also valuable on hills in conjunction with flints. Indeed, a road made of rag and flints in the proportion of two of rag to one of flints, will last longer and wear better than a road made of either material separately.

FOOT-PAVEMENTS.

In the earlier part of this paper I informed you that the town was paved in 1791. This work lasted, with annual repairs, till 1885, when, in consequence of long-continued complaints, it was deemed advisable to repair the foot-pavement of the principal streets without further delay. We advertised for samples of all the various kinds in vogue and their prices. After careful consideration, that known as Stuart's patent granolithic pavement was selected. The price was 4*s.* per yard superficial, and 6*d.* per foot run extra for the kerbing. The estimated cost was 4280*l.* The money was borrowed. Mr. J. T. Harrison, C.E., held the usual inquiry, saw the samples, and commended our choice. The loan was granted for 20 years. The work has been carried out most satisfactorily, and has met with universal commendation. Upwards of 20,000 yards superficial have been laid with "granolithic." Upwards of 6000 yards of pavements in side streets have been repaved with the best of the flagging and kerb taken up to make way for "granolithic." More than 30,000 feet run of channel gutters have been formed with the old 9-inch granite or rag kerbing, superseded by the new material. After two years' observation of the granolithic pavement, I have no hesitation in recommending it to your notice as one of the cheapest and best known pavements. It is not slippery, and dirt or snow does not hang to it as to York flagging; it also dries up much more quickly after rain. Our death-rate at the present time is only 13·00 per thousand, and our Medical Officer of Health (M. A. Adams, Esq., F.R.C.S.) has openly stated that in his opinion the improvement in our roads and pavements, by the introduction of non-absorbent materials and surfaces which prevent soakage into the subsoil, and so render the basements of houses to be drier, is a very important factor with other sanitary measures in producing the beneficial and satisfactory result by which Maidstone has been placed in the list of first-class healthy towns.

COURTS AND ALLEYS.

Like all old towns Maidstone has a number of courts and alleys, of which the dwellings are more or less dilapidated and crowded, the paving very rough and bad, the whole place dark, and the inhabitants the very poorest—hotbeds of disease and crime. The Authority has from time to time taken steps to compel the owners of these properties to improve them, and in 1886 determined to repave and light all the courts at the public expense. They have since been paved (nearly 7000 yards superficial) with Bensted's tar concrete paving. Thirty public lamps have been erected therein, and are now lighted at an annual cost to the ratepayers of 82*l*. 17*s*. 6*d*. This is one of the most useful social and moral sanitary improvements of later years.

PUBLIC HOSPITAL.

In 1881 steps were taken to promote the erection of a public nfectious Diseases Hospital. A suitable site, four acres in extent, vas secured, one and a half mile west from the town hall, at an altitude of 200 feet above sea-level. The building was completed in 1883. It affords accommodation for 20 beds. It is perfect in all respects, being constructed on the most approved and scientific principles. The disinfecting chamber, by Goddard and Massy, is heated by gas.

Cost of Hospital.

	£
Site (4½ acres)	900
Building, &c.	4557
Furniture and other apparatus and fittings..	573
TOTAL	6030

Annual cost of maintenance, about 500*l*. per annum.

Public Gardens and Recreation Grounds.

The Brenchley Gardens, presented to the town in 1872, about four acres in extent, are tastefully laid out and kept in good order. Being in the centre of the town, they are greatly patronised and highly appreciated.

In 1881 eleven acres of land were acquired at Penenden Heath, two miles north from the town hall, by gift from the Earl of Romney, lord of the manor. The plot was afterwards fenced, levelled, and planted at the expense of the ratepayers as a public recreation ground, and is a great boon to the inhabitants.

In 1885 nearly six acres of land on Barming Heath, two miles west from the town hall, were also secured as a public recreation ground by allotment on enclosure of the heath. This piece of land has also been levelled, fenced, and planted in the same way.

Sumerfield Estate.

In 1883 a plot of land, upwards of four acres in extent, lying immediately over the springs on Rocky Hill, was purchased at a cost of 4250*l.*, to prevent the possible pollution of the springs, as the estate had been laid out as a building estate for cottages. This land has hitherto been let as a market garden, but is in hand at the present time and will probably be devoted to the use of the Boys' Grammar School, in which the Corporation is largely interested, as a cricket field.

Cattle Market.

In 1883 the Corporation determined to remove the old fences and pens, and to reconstruct the cattle market in accordance with the plan I prepared. The fences and pens to be all of iron, and the pavement Bensted's tar concrete pavement. The estimated cost was 4800*l.* The work is being carried out by sections, and paid for out of the market funds.

Water.

In 1885 the Maidstone Waterworks Company obtained an Act of Parliament to enlarge their undertaking, and to obtain a new supply of water from the chalk hills at Boarley and Cossington Farms, about four miles distant, from whence it flows to the town by gravitation. By this Act the Company has secured an almost unlimited supply of remarkably pure water.

GAS.

The Maidstone Gas Company has also done its duty to the town by keeping well to the front in adopting improvements to increase the quantity and quality of the gas, and to supply it at a reasonable price, as will be understood when I tell you we are supplied with 15-candle gas at 2*s*. 6*d*. per thousand cubic feet.

Both of these companies are exceptionally well managed, and are in an exceedingly flourishing condition.

STATISTICS.

Area, 4576 acres.
1881, Population, 29,632.
1888 „ 32,300 (estimated).

1881, Annual Rateable Values, £106,251.
1888, „ „ „ £131,562.

1881, No. of Houses, 5658; average, 5·6 persons per house.
1888, „ „ 6558 (estimated).

1881, Death rate, 14·19 per 1000.
1887, „ „ 13·00 „ „

Increase of Population.	
1831 ..	15,387
1841 ..	17,805
1851 ..	20,801
1861 ..	23,016
1871 ..	26,196
1881 ..	29,632

1880,	Death-rate,		18·83	per 1000.
1881	„	„	14·19	„
1882	„	„	17·34	„
1883	„	„	18·53	„
1884	„	„	15·69	„
1885	„	„	15·89	„
1886	„	„	17·55	„
1887	„	„	13·00	„

The town is built between the—
Low level .. 20 ft. above Ordnance datum.
High „ .. 120 ft. „ „ „
The population resides at a mean of 70 ft. above Ordnance datum.

Describing the borough boundary between the angles of an equilateral triangle, the altitude at the three points are—N.E., 251; S., 245; W., 260, above Ordnance datum.

Public lamps in 1881	..	No. 514.
„ „ „ 1888	..	No. 596.

Price charged by Gas Company to the Corporation is £2 15*s*. 3*d*. per lamp per annum, which includes the cost of lighting, extinguishing, cleaning, and repairs.

Average consumption of gas per lamp is 4½ cubic feet per hour.

Length of roads, nearly 40 miles.

Area of granolithic pavements, 20,692 yds. sup.
„ „ old foot-pavements, 11,057 „ „

Length of tar pavements, about 20 miles } average 6 feet wide.
„ „ gravel footpaths „ 20 „ }

Flints broken and delivered on the roads cost 6*s.* per cubic yard.

Kentish rag stone costs about	2*s.* 9*d.*	per cubic yard in quarry.
„ „ „ „	1*s.*	„ „ for breaking.
„ „ „ „	2*s.*	„ „ „ carting.
	5*s.* 9*d.*	Total per yard.

Penlee Elvan stone costs	8*s.* 8*d.*	per ton delivered alongside wharf.
„ „ „ „	6*d.*	„ „ unloading and weighing.
„ „ „ „	2*s.*	„ „ for breaking.
„ „ „ „	1*s.*	„ „ „ carting.
	12*s.* 2*d.*	Total per yard.

Horse Keep.

Weekly allowance per horse:—Food
- 2 bus. oats.
- 1 peck beans.
- 2 bus. bran.
- 3 trusses hay (to be cut).

„ „ „ „ Litter 2 trusses straw.

Nine horses cost upon an average £365 per annum.

(Copy.)

"*Specification of Patent Granolithic Pavement, to be laid by Messrs. Stuart & Co., of Church Row, Limehouse, London, in the streets named in the schedule attached to this specification.*

"To provide all materials, water, tools, tackle, implements, coverings, guards, platforms to give access to the shops, &c.

"To provide all lighting and watching, and to take all responsibility in case of accidents or damage of any kind whatever.

"To excavate the ground, and level the same to an uniform depth of 6 inches below the desired finished level of the surface of the pavement.*

"To cart away the whole of the surplus earth, and to provide all carting of the necessary material for the formation of the new pavement.

"To provide and lay in concrete square boxes 3 inches clear internal measurement for all gas and water service-pipes where required to every house.

"To raise or lower as the case may be, and refix to a proper level all channel gutters or pipes, coal plates, area or cellar gratings, windows, &c.

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* The Corporation undertook to lift and cart away the old flagging.

"To make good to all house fronts, steps, &c.

"To provide and lay on the excavated ground a hard core foundation of a thickness of not less than 2½ inches, properly levelled and prepared to receive a Portland cement concrete bed gauged six to one (i. e. six parts of approved shingle to one part of Portland cement, weighing not less than 112 lbs. to the striked bushel).

"To lay on this concrete bed not less than 1½ inch of Stuart's patent granolithic pavement material in the proportion of two parts of crushed and prepared granite to one part of Portland Cement, specially manufactured by Stuart & Co., at their Cement Works, Cliffe, Kent, weighing not less than 120 lbs. to the striked bushel. These two latter substances or thicknesses are to be laid simultaneously. The surface of the pavement to be properly indented with rollers.

"To V groove half an inch in depth at least all crossings over the pavements which may be used for carriage traffic in straight lines or crossed to form squares.

"To form a kerbing of patent granolithic material eleven inches wide on face and nine inches in depth along the whole line of paving.

"Provide and fix iron guards to protect the kerbing at all corners of the pavement where required by the Borough Surveyor. The guards to be not less than 10 feet long, 9 inches deep, and ¾ inch thick of wrought iron set to the necessary curves.

"The whole work to be done to the entire satisfaction and under the direction of the Borough Surveyor."

(COPY.)

Letter re Analysis of Maidstone Pressed Sewage Sludge and Effluent.

"*October 20th*, 1885.

"FRANCIS J. C. MAY, ESQ.,
BOROUGH SURVEYOR, MAIDSTONE.

"DEAR SIR,—We are sorry that our examination of the samples of effluent water sent by your Board is not yet complete. In the meantime, however, we send you the results of the analysis of the wet and dried sewage sludges. For the sake of comparison we have given the analysis of the wet sludge, both in its natural state and in the dry state.

"From the figures it would appear that the drying of the sludge involves practically but very small loss of ammonia. In the dried state the sludge is free from objectionable smell, and can be readily stored and sold in a convenient form. The wet sludge, though remarkably dry for a merely pressed sludge, is not in a condition, we think, in which it would command a ready sale. It would, however, not be necessary to dry it to such an extent as has been done with the dried sample you sent, in order to make it in a more marketable condition and free from any nuisance.

"The dried sludge we consider to be worth from 12*s.* to 15*s.* per ton.

"We hope shortly to hand you full report,

"And remain,

"Yours faithfully,

"AUGUSTUS VOELCKER & SONS."

(COPY.)

DR. VOELCKER'S ANALYSIS OF PRESSED SLUDGE FROM THE MAIDSTONE WORKS.

October 20*th*, 1885.

	Wet Sludge.	Wet Sludge calculated dry.	Dried Sludge.
Moisture	35·97		2·85
Organic matter, &c.	17·35	27·03	25·61
Phosphate of lime	1·38	2·16	2·05
Carbonate of lime	23·33	36·45	35·20
Sulphate of lime	·24	·39	1·03
Lime	·95	1·49	4·86
Oxide of iron and alumina	3·47	5·42	4·52
Potash	·14	·22	·12
Chloride of sodium	·06	·10	·10
Soda	·21	·34	·31
Magnesia	·39	·61	·59
Insoluble silicious matter	16·51	25·79	22·76
	100·00	100·00	100·00
Nitrogen	·66	1·04	·89
Equal to ammonia	·80	1·26	1·08

AUGUSTUS VOELCKER & SONS.

(COPY.)

Letter and partial Analysis of Sewage by Dr. Voelcker.

"*December* 19*th*, 1885.

"FRANCIS J. C. MAY, ESQ.

"DEAR SIR,—We are sorry we have not been able to complete the analysis of the Maidstone sewage in time for your meeting of Monday.

"We may inform you, however, that the results obtained at present are as follows:—

	Grains per gallon.
Total solid residue (in filtered sewage)	210·84
Lime	8·46
Oxide of iron alumina	
Phosphoric acid	2·24
Soluble silica	4·48
Magnesia	2·02
Chlorine	13·51
Sulphuric acid	7·50
Free ammonia	6·30
Albumenoid	2·52
Suspended matter not yet determined	
Alkalies (potash and soda)..	

"You will observe that the sewage does not differ very greatly from the effluent.

"We will send you on the report as soon as possible.

"We are, dear Sir,
"Yours faithfully,
"AUGUSTUS VOELCKER & SONS."

(COPY.)

Letter and Analysis of Maidstone Sewage by Dr. Voelcker.

"*December* 22*nd*, 1885.

"FRANCIS J. C. MAY, ESQ.

"DEAR SIR,—We have pleasure to hand you herewith the result of a careful analysis of the sample of Maidstone sewage.

"The sewage contained in an imperial gallon :

	Grains.
Suspended matter	55·58
Consisting of :—	
Organic matter	43·26
Mineral matter	12·32
	55·58

"After removal of the suspended matters the sewage contained in an imperial gallon:

	Grains.
Total solid residue	210·84
Containing:—	
Lime	8·46
Magnesia	2·02
Oxide of iron and alumina	·99
Phosphoric acid	1·25
Sulphuric acid	7·50
Chlorine	13·51
Equal to chloride of sodium	22·26
Potash	10·05
Soda	45·13
Soluble silica	4·48

"Oxygen required to oxidise:

Organic matter	25·90

"The sewage further contained:

Free (saline ammonia)	6·30
Albumenoid (organic) ammonia	2·52

"The sewage was highly coloured and excessively foul. On comparing the results of this analysis with those of the effluent from the tanks analysed previously it will be noticed that there is remarkably little difference; in other words, the effluent sewage is nearly as pollute as the raw sewage. The raw sewage contains about twenty grains more suspended matter than the effluent and very much more albumenoid ammonia and more phosphoric acid. *From these results it is apparent that the treatment of the sewage is extremely imperfect, and the large quantity of suspended matters in the effluent clearly point to the fact that the sewage has not sufficient time allowed to it for settling.*

"We have tried a number of experiments on the sewage with a view of efficiently clarifying and purifying it, and have come to the conclusion that it will be practically impossible to purify the sewage by any precipitation process, without using such an enormous amount of precipitants as to put the process entirely beyond practical working owing to the expense.

"We have clarified the sewage, but only by using an excessively large proportion of precipitants.

"The difficulty of treating this sewage is due to the large quantity of alkaline waste from paper mills, &c., contained in it. This waste is very highly charged with soluble organic matters, which if removed by precipitation, as we have done in our laboratory, would only dilute the sludge which you dry for manure, and not add to its value.

"We are, dear Sir,
"Yours faithfully,
"AUGUSTUS VOELCKER & SONS."

(COPY.)

LETTER AND ANALYSIS OF EFFLUENTS BY DR. VOELCKER.

"*November 9th*, 1885.

"FRANCIS J. C. MAY, ESQ.,
SURVEYOR, MAIDSTONE.

"DEAR SIR,—We have the pleasure to hand you herewith the results of the analysis of the effluents from the sewage works at Maidstone. No. 1 is the effluent as it flows from the precipitating tanks into the river, and No. 2 is the liquid squeezed out from the sludge in the presses.

"No. 1 was a dark-coloured liquid, smelling very foully, and containing in an imperial gallon 36·12 grains of suspended matter, of which 27·16 grains consisted of organic matter.

"No. 2 was very much lighter in colour, and was practically free from suspended matter—it has also an offensive odour.

"The appended analysis of effluent No. 1 was made in the liquid after the removal of the suspended matter.

"On evaporation to dryness an imperial gallon of the two effluents left the following amounts of solid residue :

	No. 1. Effluent from Tanks. Grains.	No. 2. Effluent from Presses. Grains.
Total residue (dried at 130° C.)	183·40	670·88
containing :—		
Lime	9·56	222·18
Magnesia	1·41	·60
Sulphuric acid	7·97	5·95
Chlorine	16·90	6·30
Equal to chloride of sodium	27·85	10·38
Potash	8 95	8·25
Soda	45·46	18·00
Oxide of iron, alumina with traces of phosphoric acid	·56	1·96
Soluble silica	57·12	·42
Oxygen required to oxidise organic matter, &c.	19·60	18·20

"The effluents further contained:

	No. 1. Effluent from Tanks.	No. 2. Effluent from Presses.
	Grains.	Grains.
Free ammonia	5·88	11·90
Albumenoid (organic) ammonia	·84	9·80
Suspended matter	36·12	traces
Consisting of organic matter	27·16	
Silica, carbonate of lime, &c...	8·96	

"A partial analysis of the first small sample of the effluent from the sludge presses gave the following results:

"Partial analysis of effluent from sludge presses:

	Grains.
Total solid residue per gallon	712·60
Free ammonia	11·20
Albumenoid	9·80

"The effluent No. 1 (from precipitating tanks) is highly polluted with soluble organic matters, largely due, no doubt, to the refuse from paper mills. It contains also a very large amount of soda, which is due to the same cause. The effluent from the presses contains also a very large amount of soluble organic matter, and an enormous quantity of lime. We would recommend you to return the effluent to the precipitating tanks, where it will cause a further precipitation of the sewage, the lime being precipitated as carbonate of lime, and carrying down with it a further quantity of the organic impurities.

"Both these effluents are in a highly polluted condition.

"We are, Sir,
"Yours faithfully,
"AUGUSTUS VOELCKER & SONS."

DISCUSSION.

Mr. ANGELL: Mr. President and Gentlemen: I do not know that I have anything to add to the paper in which Mr. May has so fully dealt with the sewage part of the works. He has there generally and accurately described the system, which he is now enlarging, and I must say he has shown a very intelligent appreciation of his subject. When drainage schemes were first initiated—not so many years ago—the great difficulty the engineers had to contend with was that they were handicapped by the matter of cost. In the first place it is very difficult indeed to persuade a community to have any drainage works at all, and when you design a scheme of drainage you naturally wish to bring it within the lowest possible limit of cost. I speak from general experience, and not specially from my experience at Maidstone, when I say that a sum or limit is usually indicated beyond which you cannot go or it will be fatal to the acceptation of your scheme by the ratepayers at large, and in that sense you endeavour to get out a scheme which will fairly meet the requirements of the place. It appears that from various causes the scheme designed for Maidstone some twelve or more years ago has had to be extended, and although I have not had the opportunity of seeing that extension, I have no doubt that the extension proposed by Mr. May will be a great advantage. There are, however, one or two points in his paper to which I wish to refer, and in the first place it must be understood that some of the things he mentioned were quite tentative. For instance, the putting the sludge into holes was no part of my original scheme, but it was felt that until more definite knowledge was obtained as to the best mode of treating sewage, it would be well to hold on, and so the Corporation of that day determined that the sewage sludge should be put into holes, which, as I have already stated, was a mere tentative scheme which could only last for a time, and formed no part of my original design. There is a much better appreciation of sanitary matters at the present day, and people are understanding the importance of sanitary work —the importance of having pure air and unpolluted water—and there is not so much difficulty now as there was in former days in persuading them to expend money on sanitary works. There is one point I was pleased to hear referred to—the refuse from the Tovil Mills. That was formerly looked upon as a great difficulty, as it polluted the river very much, or was, rather, offensive in its results. An immense amount of white foamy matter used to come down from the mills, and had a very peculiar effect, especially at the locks, where some acres of the river surface was covered with white foam. That has been turned into the sewers with the great advantage of deodorising the sewage. There was some little doubt whether the chemicals contained in the refuse from the mills would have a damaging effect on the structure of the sewers, and perhaps Mr. May will tell us if that has been the case?

Mr. MAY: Not in the least.

Mr. ANGELL (continuing): One great fear I also had was with reference to the water supply. Mr. May has stated in his paper that the Corporation have not felt it incumbent on them to compel a constant supply to all the closets in the town, and there was a great fear in my own mind whether the sewers would not become offensive on account of cesspools overflowing into them and without proper flushing. In fact, before the works were completed we did find a great deal of solid matter getting into them. It is absolutely necessary there should be a complete flushing of every house drain, or you will get a deposit in the sewers. It is satisfactory to know that the effect of the works—before they were extended—has been to clear the town of filth, and also the river, which was in a deplorable state when I became acquainted with it, especially between the locks. I have nothing more to add, except that looking back twelve years, I wish to acknowledge the courtesy I always received from the Corporation, and the great assistance they gave me in this matter, especially Mr. Alderman Ellis, who I see is still chairman of the Drainage Committee. I remember with great pleasure the interest and energy that gentleman always threw into the work and the valuable assistance he gave me on all occasions.

Mr. **Ellice-Clark**: I do not wish to criticise the whole paper, which is a large umbrella and covers a great deal of ground, but there are one or two points in it on which I hope Mr. Angell or Mr. May will give us some further information. The author of the paper says the Maidstone sewers are divided into sections for the purposes of ventilation, and that was to prevent the sewer air passing from the lower to the higher levels. I should like to know whether observations were made to prove that the air was constantly passing from the lower levels to the higher levels, because recently experiments have been carried out forming a series of continued observations by the Surveyor of Wimbledon, which go rather to prove the contrary—that the air is passing more frequently down the sewers than it is up them. That is also my own experience in a number of cases. Probably that is accounted for by the fact that the direction of the wind has more effect upon the ventilation of sewers than anything else. There is another matter of detail on which some information would be useful. Mr. May tells us that when accepting tenders for granite it is examined and tested, and as it is a matter of practical importance to know how granites are examined and tested before they are put on the roads, I shall be glad to know what kind of examination was adopted, and what series of tests were instituted. Maidstone is rather famous for producing excellent tar paving, and I believe that in some of the best tar paving executed in the south of England, the stone comes from this district. In reference to this matter I have just this suggestion to offer to those who propose to use tar paving largely in the future. Instead of putting down tar paving of the character in which the bituminous concrete is six inches thick—the latter costing more than Portland cement concrete, the lower part should consist of four inches in depth of cheap coarse concrete mixed in the proportion of about ten or twelve to one. I have laid down footpaths with a concrete of that kind—and then put over it half an inch of tar paving, and have found it answer very much better than where the bituminous concrete is laid all the way through; and a large number of suburban paths may be paved very much better and cheaper in that way than they have been hitherto, and you know very well from experience that local boards will not pave suburban paths because of the great cost. If you lay cement concrete almost to the surface, then float it off and simply tar it over, strewing a very fine gravel over it, you would get a first-rate path which might be renewed once in two or three years, according to the traffic, and probably the cost would be something less than a halfpenny per square yard per annum.

Mr. SANTO CRIMP: Before offering any remarks on the able paper read by Mr. May, permit me to congratulate the Corporation of Maidstone on the adoption of the very handsome stone bridge we passed over this morning. All engineers will agree as to the wisdom displayed in the choice of stone for that very elegant structure. With regard to the ventilation of sewers, I may mention that for nearly twelve months I have been making experiments at Wimbledon as to the direction of the currents, the results of which I hope shortly to lay before the Association. I may say, however, that those experiments have convinced me that the prevailing current may be downwards and not upwards, as we have hitherto been led to believe, not only by the big-wigs of Westminster, but even by Sir Robert Rawlinson, late Chief Inspector at the Local Government Board, who you will find does not say one word about preventing your gases travelling downwards, but he does say you must do all you can to prevent them going upwards. At Wimbledon we have suffered much inconvenience from the gases created in the sewers in the hills, and passing down to an outfall at a lower level, which outfall is an excellent one, but it had got a very bad name simply owing to its being a receptacle for gases. Since the branches passing up the hills have been trapped off, complaints with regard to offensive smells from the outfall have ceased. As to the question of sludge presses, I may mention that I have had three years' experience of that matter, and therefore I may claim to know something about it. I do not agree with some of the conclusions come to by Mr. May. I think, considering the position in which you are placed here, that the presses are the best method you could adopt, and I am glad to see them put up here, but you do not get all the advantages of this particular form of press that the author tells you he does. He tells you that you get greater rapidity of filtering, whereby the cakes are turned out in half-an-hour, working with a pressure of 80 lb. to 100 lb. to 1 square inch, and that you get five tons per day of ten hours. At Wimbledon we have two presses of 24 cells, as compared with two presses of 30 cells at Maidstone, and by the pneumatic process we turn out 6 tons 1 cwt. per day with perfect ease, and with a pressure of only 50 lb., which exceeds the work done by the Maidstone presses with a larger number of cells. If we had thirty chambers—the same as you have here—we should be getting out 7½ tons per day. Therefore there is no economy of time in the presses, as claimed for them, but rather to the contrary. I quite agree that here you effect a saving in the cloths, which is rather an expensive item with us. I find, on working out the figures of the Maidstone system, that the cloths cost 2·03*d.* per ton, compared with 2¾*d* per. ton at Wimbledon. You have there a saving of two and a half per cent., but I would like the author of the paper to say what the sludge costs per ton for pressing. It costs 2*s.* 4½*d.* per ton at Wimbledon, and 2*s.* 6*d.* at many places, while at Leyton it is 1*s.* 9*d.*, and I should like Mr. May to tell us what it costs per ton at Maidstone, because after all that is the real crucial test. There is one question I should like to ask with reference to the treatment of your sewage. At the end of this paper there is a very important report by Dr. Voelcker, who points out the difficulty you have in treating your sewage, owing to the waste from the paper works at Tovil, which is highly charged with alkaline matter, and we all know you cannot precipitate such sewage by means of an alkaline carbonate like lime, and I should like to know whether you have tried the use of acids such as sulphate of alumina in precipitation, because lime will only add to the alkaline nature of the effluent. Dr. Voelcker has, however, stated in his report, that your sewage cannot be purified by means of chemicals, and that being so, I should like to ask if there is no other means of treating the sewage of Maidstone than by going to the great expense indicated by the plans now before us. You are told by chemists that what you have to do is to clarify your sewage, and that, as you know, can be done by filtration without the addition of an ounce of chemicals of any kind. Certainly it may be done in many ways much more cheaply than by the process proposed here, and I should have thought that in a district like this it would have been possible to procure land for the treatment of your sewage either at the outfall near the locks or lower down. I should also like the author of the paper to give us any information he may have as to the superior efficiency of elevating wheels over ordinary pumps. The design of the tanks appears to be everything that one could wish; their capacity is quite sufficient, and the only regret one can have is that they should have to be built at all.

Mr. **Strachan**: As to the ventilation of sewers, I have come to the conclusion that before that question is settled, we shall require much more delicate instruments for measuring air currents than I can find at present. I have been trying the effect in shafts 4 and 6 inches in diameter, and the result is that under very equable conditions for getting the current out of the sewer into the shafts, it goes so slowly that it will not even turn the wheel of a very delicate anemometer. I believe we have a great deal to learn about sewer ventilation, particularly with reference to the travelling of gases. It is somewhat bold to say they do not travel upwards, because our friend Mr. Lowe, of Hampstead, is suffering a great deal from the gases that do travel up from the heart of London to the higher districts. That is a fact that no one can gainsay; and the fact that gases do travel upwards is, I think, incontrovertible. On the other hand, we all know by careful and reliable experiments that they do travel downwards at times, though prevailingly they travel upwards. The subject of sewer ventilation will probably be more than ever discussed, and when all the doctors get together we may probably arrive at some definite conclusion. There is a good deal of evidence that sewer gases do travel upwards, though Mr. Santo Crimp says they travel downwards.

Mr. **Godfrey**: I should like to say one word as to this question of the current of air in sewers. One element which largely influences the current of air is the depth of the sewage, and I can quite understand that where you have a largely filled sewer with a strong current of sewage in it, the inducement will be for the air to go downwards; but I believe, from my own experience, that in hilly districts the gases rise upwards. On a frosty day you will see, in a long length of sewer in a gradual rise, that the ventilators in the lower parts are perfectly dry, but on the higher parts you will see the warm air moistening the soil round the edges of the ventilators, and that I think is conclusive proof that the gases do rise. No doubt the geographical contour of the country or district which you are draining very largely influences the current of the gases, and, as Mr. Crimp reported, I can quite believe that in the lower-level sewer there may be an induced current downwards; but what most of us have to contend with is the smells arising from sewer gas in new sewers. The smaller the quantity of sewage the more the smell, and I believe we have been all coming to the conclusion that until we get our sewers well filled and a good current of sewage in them, the smells will not decrease. Until that is the case, there is no doubt the gases will rise. I have been experimenting myself on the rising of sewer gas, and I have not yet come to the conclusion that the gases go downwards. I have, as it happens, two sewers in one particular road, one of great depth, and the other not so deep, and presently I hope to be able to compare notes with Mr. Crimp.

Mr. Baker: I believe we have met here to-day for the purpose of criticising the scheme brought before us by our worthy friend and brother surveyor, Mr. May. I should like to ask him how he proposes to carry the sewage to the point as shown without interfering with the tank: whether he proposes to add the lime treatment before it goes to the wheels or afterwards? It seems to me that there will be a great difficulty in keeping the wheels clear of the rags and other heavy material conveyed in the sewage. Unless some arrangement is made similar to Baldwin Latham's screen at the Coventry works, the buckets would fill up and become perfectly useless. It also seems to me there is a very long distance for the sludge to travel from the new tanks down to the sludge pumps, and, judging from the experience I have had, I think you will find there will be very great difficulty in getting the sludge to travel such an enormous distance without some mechanical means.

Mr. C. Jones: I am sure we must all feel gratified by the very able and interesting paper Mr. May has put before the association, whether we agree with all its details or not. Some of the points raised admit of much discussion, and I think the Corporation of

Maidstone will see, from the course the discussion has taken, that we deal very freely and fairly with whatever comes before us, whether it be from our brother May or any one else. Our great object is to ascertain the truth, and of course on matters such as are under discussion, it is evident there will be a great variety of opinions. Personally I quite agree with Mr. Godfrey that the physical contour of a country affects the current of sewer gases; and as the subject is shortly to receive special attention I have no doubt ‘the doctors" will agree in coming to that conclusion. I do not know if Mr. Crimp was quite understood when he referred to the tanks Mr. May proposes to put up. I would ask him, therefore, to explain what he did mean. I think he meant—and I should quite approve of the idea myself—that there should be tanks whatever system is adopted, whether filtration by land or not. I should like to clear away any doubt on the subject, so that it may not rest upon the minds of any one present that we hold antagonistic views as to the use and construction of tanks. I think it necessary there should be tanks whether the land is irrigated or not. As to the cost of pressing I deem it most important we should have something very definite on that point. It is exciting great interest at the present time, especially among those who have anything to do with the treatment of sewage by precipitation, and it is a question too, in which all Town Councils are more or less interested, because, as Mr. Angell told us just now, whether in the drainage of a town or the pressing of sludge, they are most sensitive as to the cost. I have no doubt Mr. May will give us a reasonable reply to that question. As to the value of the pressed sludge, that is a question upon which I should join issue with Messrs. Voelcker, with all due deference to those gentlemen. Undoubtedly a thing is worth what it will fetch in the open market; but if you think you are going to get from 12*s*. to 15*s*. per ton for your pressed sludge, you are, I am afraid, very much mistaken. I am sorry when I see anything of this sort put into public print, because it leads the ratepayers to suppose that your engineer is capable of doing a great deal more than it is in any way possible to do. If you can prove to me or any one else that this stuff, after it has been pressed and dried, ground into a powder, and manipulated in all manner of ways, is going to fetch even 2*s*. 6*d*. per ton—to say nothing of 15*s*., I should say you ought to have a gold medal struck for the man who can bring about that desirable result. I have had to deal with sludge for some years, and this is the conclusion I have arrived at. I say that by all means let the ratepayers of Maidstone have it impressed upon their minds that there is not one atom of value in the pressed sludge; that it is in fact a nuisance to be got rid of. I urge this strongly, because I have seen so much disappointment arising from the ridiculous notion that a large profit is to be made out of the sludge, and I think when we come to a town like this it is our duty to disabuse the minds of the ratepayers of any such erroneous idea. I wish, however, to thank Mr. May for his very interesting paper, and I think enough has been said to show that our gathering to-day may be of some use from a practical point of view.

Mr. **Goodyear**: I should like to say, in reply to Mr. Jones's remarks as to the value of the pressed sewage, I think I am right in stating that the town of Salisbury has been making 3*s.* 6*d.* per ton of their sludge for the last few years. We have just adopted the pressing system at Colchester, and we have a great demand for the sludge at 2*s.* per ton, and I hope to raise the price to 4*s.* next year. We cannot make the stuff fast enough. Of course we are favourably situated, being in the midst of an agricultural district, and we have some market gardeners around us; but I do not say that the stuff is worth 10*s.*, 12*s.*, or 13*s.* per ton, as some of the analysts say it is, but I do think we shall be able to make 4*s.* per ton of it in future.

Mr. **Meade**: I cannot allow this meeting to close without adding my very sincere thanks to those already expressed to Mr. May for the very admirable paper he has favoured us with to-day. I think, too, it should be clearly understood that what is stated here to-day is being said before the speakers have seen the works. Happily I am not in that position, for I have seen the works, and came away very pleased with the manner in which the pumps and presses are doing their work. I came here quite unexpectedly and saw them doing their ordinary work. I should like to ask Mr. May the quantity of lime added to the sludge before it is admitted to the presses. With regard to the ventilation of sewers, I may mention that the district I represent is perhaps one of the most hilly in the neighbourhood of London, and we are connected with a number of sewers on the lower level. There is no doubt in my mind that the gases travel up and not down. Some few years ago we had considerable complaints, and I found that by dividing the sewers into sections, and putting flaps in at different points, commencing with the low-lying portions and working upwards, we got rid of the complaints in the high-level districts altogether, thus showing that without division by flaps or otherwise, a great quantity of gas passed the lower ventilators, and made its way to the higher levels, causing a great nuisance.

Alderman **Ellis**: As a member of the Corporation this question of the disposal of the sewage of Maidstone has interested me a great number of years, and I suppose I must plead guilty to having involved the town in an expenditure of 60,000*l.* I have listened with great interest to the discussion to-day, and have heard with much concern what has been said as to the value of the sludge. Well, doctors will differ—even about the value of manure. A gentleman on my right says the sludge is of no use, and another gentleman on my left says it is worth 4*s.* per ton. Then with regard to the direction of sewer gases, some say they travel downwards, while others say they go upwards, but I think we are pretty safe in going on with the project we have in view, unless you can tell us something better. It is said by one gentleman that we should not increase our tank accommodation, but that we should pass the sewage through filter beds, and thus obtain the same results; but we have tried the filter bed, and did not get the pure effluent we do at the present moment. I saw the other day in the *St. James's Gazette* a paragraph referring to the treatment of sewage of Chichester barracks, where the authorities were threatened with law proceedings. They set to work with a new process, and have so effectually cleared the effluent that it runs without harm into a brook there. The same system is in operation at Windsor Castle, and has also been introduced at the Junior Civil Service Club. The sewage is treated with a solution of iron, and I should like to hear if any gentleman knows anything about the treatment, and can give us his opinion whether we should require tank accommodation or not; because as I understand it this thing can be used in the house itself, and the effect is merely a slight deposit of an iron dust at the bottom of the pipes. Before starting upon a considerable outlay in regard to further tank accommodation, one would like to obtain further information, and to know the views of this meeting on the subject.

Mr. **Angell**: One word of explanation arising out of the remarks made by Mr. Jones and Mr. Crimp as to the tanks. I forgot to say that the tanks were placed where they are as the most favourable position for pumping over land in the future.

There was great difficulty in fixing on a site in this district, and this one was fixed upon as the best possible one for a pumping station, the outfall itself being quite a mile lower down.

The **President**: I was very glad to hear Alderman Ellis chairman of the Drainage Committee, invite even further discussion, but as our time is getting on I am afraid we must bring the discussion to a close. I hope that the gentlemen of the Corporation here to-day will not think the paper has been dealt with unmercifully. The criticism has been of a very mild character; several points have been touched upon, and I think that what the Corporation of Maidstone would most like to hear is something with reference to the scheme upon which they are now embarking, as to whether or not it meets with the approval—so far as it can be judged from the description we have heard to-day—of this Association. You have heard from one gentleman that he is somewhat afraid that more money is likely to be spent on these tanks than is necessary, and that the same end might have been attained in another way. Well, I must say that I think probably it might not have been necessary to go to quite such a large expense as is proposed here, and even supposing filters cost as much as tanks I think there is no doubt they are an advantage, inasmuch as they give you a better effluent than you can get by precipitation alone, especially by lime. You get matters in solution taken from the sewage itself by passing it through land or filters. By the use of lime, your effluent—however well you may have taken out the solid matters—will be of a very alkaline character, and I notice that Mr. May uses a ton of lime to a million gallons, and that is equal to sixteen grains per gallon. That must give a very alkaline effluent, and if it were not that you have a large river into which to pour your sewage, I venture to say you would have second putrefaction. But I must say this, that with the number of tanks you are proposing to use, equal to a day's supply in dry weather, and the comparative capacity of which to your daily supply I am not aware has been attempted anywhere else in the country, you ought to be able to get the most transparent effluent that the lime process will produce. Even Bradford and Sheffield, which have excellent tank accommodation, are better provided than you propose to be at Maidstone. But I think it might be well for the Corporation to turn their attention to other processes in connection with lime. Mr. Ellis has asked a question with reference to the use of iron. I have not seen the paragraph in the *St. James's Gazette*, but you would certainly want tanks if you adopted the iron process. Mr. Santo Crimp threw out a suggestion that you might add alumina because your sewage is already of an alkaline character owing to the refuse which passes into it from the paper mills, and I have no doubt you could take out a great deal of that alkalinity by the use of other chemicals, but I should hope that if you carry out your proposed tanks you will not want other chemicals, for I can assure you, from a considerable experience in the use of chemicals, every chemical you use beyond lime will cost you a great deal of money. Sulphate of iron, sulphate of alumina, and many other chemicals have all been more or less tried at Leicester, and have proved to be three, four, and five or six times the cost of lime, and so long as your alkaline effluent does no harm in the river you may obtain with lime a sufficiently clear effluent by its use alone. I do not see why your process should not be successful under the conditions I have named; and I am sure we are all glad to have heard the paper from Mr. May. It only confirms the impression that you have in him a surveyor who can deal satisfactorily with the sanitary requirements of Maidstone and keep it abreast of the science of the day. I think the Corporation are also to be congratulated very much on the success they have achieved in all the other works to which Mr. May has alluded. The foot bridge we are told was a second-hand purchase, and therefore whoever was responsible for that was keeping an eye on the purse of Maidstone. The stone bridge is a great credit to the town and also to Sir Joseph Bazalgette, and I believe we are all coming round to the opinion that stone will in future take a much larger share in works over rivers than iron. Something has been said by Mr. Angell about the difficulties engineers have even now as to the matter of cost; but I venture to say that the cost of the Maidstone sewage works, 60,000*l.*—for which Mr. Ellis considers himself largely responsible—is not excessive for 30,000 people, and it may be some comfort to the ratepayers of Maidstone to know from those who have had considerable experience in these matters, that they have works of full value, and that they have not been an excessive cost to the town when compared with other works of the kind. There is one matter I should like some information upon. You have a syphon here under the river, the size of which I should like to know, and whether it is always kept clear. The outfall sewer has, I notice, a very flat fall, and as it is on occasions of this kind that we obtain information which guides us in other schemes, I should be glad if Mr. May will tell us whether the fall of one foot per mile has been found to be sufficient and self-cleansing. With regard to the sludge I do not think you will get a greater quantity of dry sludge in future than is anticipated by Mr. May.· You are now getting from your present tanks 45 tons of dry sludge per week, and that means something like about 32 tons of wet sludge per million gallons, which is about the quantity obtained from all kinds of sewage. What is most interesting to know is the cost of pressing wet sludge into dry, and I hope your difficulties will not increase under that head. Mr. Jones has referred to the hospital, and to the gas disinfecting apparatus there. On this head I may say that a gas apparatus does not totally destroy the germs of disease, and that the only proper and efficient disinfector is by means of steam. I will not further occupy your time except to say that I am sure you will all have very great pleasure in according Mr. May a most cordial vote of thanks for the highly interesting and instructive paper he has read to us to-day. I need not put the motion formally, because I am sure I have only need to mention it to ensure its being carried with acclamation.

Mr. MAY: With regard to the queries as to the presses and the cost of pressing, &c., &c., I will reply to them at the works, where I can explain everything in connection with them more satisfactorily, and make myself better understood than I can in this room. As to using land for filtration, I quite agree that a better effluent can be obtained by that means than by precipitation; but I think when you go to the outfall works you will see that we have no opportunity of obtaining land suitable for filtration. Therefore we were driven back upon precipitation in tanks, and I think you will find the situation of the tanks is quite unique. I may tell you that we had hardly an inch of level ground, except what we have made for ourselves, and the land below is so subject to floods and other inconveniences, that we were led to the conclusion we must adopt the proposed mode of treatment. With reference to the outfall sewer, you have asked whether it is a self-cleansing sewer, and I must tell you it is not. In fact two or three years ago we found it was silted up to a considerable extent, and that is accounted for in two ways: not only because the gradient is very flat, but for a considerable time in the day it is merely a reservoir for the whole of the sewage which is kept back by the tide, and precipitation takes place during that period. By permission of the Medway Lower Navigation Company we were able to get out of that difficulty, because they allowed us to take water by means of a penstock and culvert from the river, so that when the tide will permit, we are able to pass an immense quantity of river water into the outfall sewer, and thus cleanse it of any deposit which may have taken place. The syphon under the river has been self-cleansing. At one time we had a little difficulty with it, because the manhole on the west side of the river was so small that the solid matter often choked it, and we were unable to get at it to clear it away. Three or four years ago we considerably enlarged it, and we then found that the syphon was silted up to a considerable extent. We cleared it out, constructed a larger chamber, and it has answered very well since.

Mr. ELLICE-CLARK: Has the syphon any fall?

Mr. MAY: No, I think not.

The PRESIDENT: What is the size of it?

Mr. MAY: (Two feet six inches in diameter.) With reference to the sewer ventilation, we always find that on the higher levels we have much more smell than in the lower parts of the town, and we also notice the same condition of things explained by Mr. Godfrey, that while the ground is perfectly dry round the ventilators of the lower levels, it is always moist round the ventilators in the upper levels.

The tests of granites, on which I relied, were as follows:—

STRENGTH TESTED BY DAVID KIRKALDY, TESTING WORKS, SOUTHWARK STREET, LONDON.

	Pressure on 1 square inch crushed at	Pressure on 1 square foot crushed at
	lb.	tons.
Penlee	29·011	1865
Cliffe Hill	21·687	1486
Bardon Hill	20·742	1334
Markfield..	19·096	1228
Mountsorrel	17·538	1128
Guernsey	15·062	970

I tested the several kinds of granite to learn their powers of absorption by keeping them immersed for one week, each in the same given quantity of water, in vessels of equal sizes and in the same place. The result was that Penlee had absorbed much less than the others, although the quantity in each case was very small.

I further tested them by the use of hydrochloric acid, to ascertain if there was any appreciable amount of lime in the stones. The test had very little effect indeed on any stone, but none whatever on the Penlee stone.

There is no available land within a reasonable distance which is suitable in the least degree for filtration, neither as relates to its character nor its position. The treatment of sewage effluent by filtration through land has in no way been overlooked by me, but I have been obliged to give it up as hopeless. Therefore I am compelled to fall back upon the system of precipitating tanks.

I have already tried the use of sulphate of alumina as a precipitant, but owing, as I believe, principally to the small capacity of my tanks, the little extra improvement in the character of the effluent was not at all in proportion to the additional cost. I therefore discontinued its use.

I have given a deal of time to the study of the question of elevating wheels for lifting sewage, and recommend their use (in certain cases) in preference to pumps, for the following reasons:

1.—There are less moving parts.

2.—Consequently less friction, therefore less wear and tear.

3.—The less the friction, the less motive power required.

4.—The reduction of motive power also reduces the annual expense for fuel and attention.

5.—A wheel has no valves to get out of order.

6.—There are no glands to pack occasionally.

7.—The annual repairs of a wheel will practically be nil, the only wearing part being the centre bearing of the wheel.

8.—In a wheel there are not, as in pumps, valves which may become choked or stopped.

9.—A wheel is always regular in its delivery, uniform in its action, and by its motion will assist the incorporation of the lime with the sewage.

I cannot see there is anything to substantiate the idea that in lifting the raw sewage after it has been screened, the buckets will be liable to become choked with sewage. They will be 2 feet 6 inches wide, and will each hold 1·75 cubic feet of sewage. The bottom of the bucket will be round, and there will be no angles at the sides for anything to cling to. When upside down they must deliver their contents.

The drain by which the sludge will flow from the tanks to the reservoir will have a gradient of one in 160. I have already proved this fall to be sufficient for the purpose.

The lime for precipitation will be added to the sewage before it is lifted by the wheel.

I have taken the pains to work out the actual cost of a ton of pressed sludge, and I find it has averaged 1*s.* 4½*d.* per ton.

I have also turned out 24 pressings from each press in 12 hours, each averaging 18 cwt. of pressed sludge, or a total of 21 tons 12 cwt. At the same time I used only 1½ cwt. of lime to 10 pressings, or 1½ cwt. lime to 9 tons pressed sludge. I have also made a few pressings without any additional lime in the sludge.

I am sure that the cost of filtering material per ton may be much reduced, as I feel confident, from my observations, that if our presses were working continually, the wear and tear of the filter mats would not be much more, if any more, than at present. I have already stated in my paper that the coir fibre mats will last much longer if continually wet, as they would be if constantly at work, than when worked intermittently, so as to be alternately wet and dry. The cost of our filtering material has been 2*d.* per ton, but if we had pressed 11 tons instead of 5 tons per day, I am sure it would not have exceeded 1¼*d.* per ton.

I beg, Mr. President and gentlemen, to thank you very sincerely for the vote of thanks you have so kindly accorded me, and will, with your permission, reply to the other questions at the tanks.

AT THE TANKS.

After lunch the party proceeded down the river in a barge drawn by Messrs. Drake and Muirhead's steam launch, and on arriving at the works they made a thorough inspection of the screens, tanks, presses, engines, and the premises generally, under the guidance of Mr. May. This part of the programme completed, there was an assembly in the press-room, where the discussion was continued.

Mr. May: Mr. Crimp appeared to think that 5 tons per day was the capacity of each press, but that is an error. Five tons per day was the actual quantity turned out; we have disposed of all the sludge we have to deal with, but if we had 11 tons per day we should be able to deal with it, working twelve hours per day. We are now using seven bushels of lime to ten pressings, which is equal to 4½ cwt. of lime to 180 cwt. of pressed sludge; in other words, 1 cwt. of lime to 2 tons of pressed sludge. The proportion of wet sludge to pressed cake is as five to one; i.e. 18 cwt. of pressed sludge represents 90 cwt. of wet sludge. We have five men on the works, and two men do the whole of the labour of this room. The stoker attends to the boiler and the machinery in the shed below. He is a kind of odd man. The same two men would work three presses.

Mr. Goodyear: I should like to ask Mr. May whether the present pump is sufficient to supply the three presses when they are put up, or whether it is contemplated to put up more pumping power?

Mr. May: It is thought more convenient to put up another pumping engine, for the simple reason that if the existing one were to break down we should have something to fall back upon. We simply propose to duplicate the system so as to be able to deal with any contingencies which may arise. All our houses are connected with the sewage system. The increase in the quantity of sludge which I anticipate, will arise from the better mode of precipitation. At the present moment our tanks are filled by the volume of sewage, and the empty tanks are filled in an hour and a half. A proper amount of precipitation does not follow; but with an increased amount of tank accommodation our effluent will be rendered much purer by the extra precipitation which will take place in the tanks.

Mr. Pilditch: If either of these presses broke down the remaining press would not be sufficient to do your work, and that, I suppose, is the real reason why you want to put in an extra press?

Mr. May: Yes; that is so.

Mr. Godfrey: I understand that what Mr. May says is that if he has more tanks he will get more mud, and if you do not have plenty of tanks you don't get the mud.

Mr. May: Exactly so. My object in extending the works and duplicating the machinery is that we may settle our difficulties once for all. I ought also to explain that at present our effluent is not satisfactory to the authority into whose district it is discharged; and one reason why we propose these extra works is that we may obtain such an effluent as our neighbours will not find fault with.

The President: I take it that Maidstone is purely a water-closet town, and therefore you get a greater amount of sludge than they do in the Northern and Midland towns, where the pail system is in vogue?

Mr. May: That is so. A suggestion was made this morning that it might be possible to abolish our system of new tanks and adopt a system of land filtration, but I think that now you see the position of our land you will agree that filtration is utterly out of the question. I venture to say that the position of these outfall works is quite unique, and that not a gentleman present can speak of any other works similarly situated. Two or three years ago I prepared a scheme for pumping the whole of the sewage on to the high land beyond us here—the only land available for filtration—but when we went into the cost we found it so enormous that we were bound to give it up, and that drove us back to our system of precipitation pure and simple. If we had gone on to the ground I proposed, the weight of the lift would have been 85 feet from the sewer, the outfall being a mile below this spot There is not a single yard of land available for filtration. The contour is very similar to this for miles below.

Mr. Angell: There is one thing which should be known, viz. it was considered a matter of great importance that the tanks should be hidden because the river is a pleasure river which people go up and down every day, and it was very necessary the tanks should not be seen from the river. That was one reason why we put them down in this "unique" place.

Mr. Muirhead: Before you leave, gentlemen, I should like to explain one or two matters upon which some misapprehension appears to exist. From certain correspondence which has passed through our hands, and also from some remarks I have heard this afternoon, there seems to be an impression in some minds that we, by having adopted this direct-pressure pumping arrangement, are handicapped with a serious loss of power, whereas, in fact, we claim an advantage. Only a few minutes ago I heard one gentleman telling another that because we use direct-pressure pumps, there must of necessity be a great deal more sludge pumped than is actually required, and that the excess must consequently be pumped to waste through some hidden outlet or relief valve. Now I wish it to be clearly understood that, although the above remarks might have been correct if made in reference to previous attempts to solve the same problem, they are certainly not correct as regards the case in point. I most emphatically state that there is no outlet from these pumps other than that which goes direct into the press; there is no relief-valve either on the delivery pipe or the press, and there is no safety-valve in any sense of the term. With your permission, Mr. President, I will explain in as few words as possible what is actually done. The pumping engine, you will have observed, does not work at one regular uniform speed, but starts and stops, increases and reduces its strokes automatically, and thus delivers a varying amount of sludge in accordance with the requirements of the press from time to time. When the pressing commences, the engine runs fast and rapidly fills up the cells. As the sludge solidifies and the resistance increases, the speed is gradually reduced automatically until towards the end of the operation, when there being no more room in the press the engine comes to a dead standstill. I think, therefore, I am entitled to claim that we do not pump sludge to waste, and that there is no loss of power in the way that has been stated. With regard to the best pressure to work at, it is quite true, as Mr. Crimp has said, that it is possible to get cakes with 50 lb. pressure to the square inch, but we find that better results are obtained—i. e. more solid coke with a less proportion of lime—when working up to a maximum pressure of from 80 lb. to 100 lb., and as in our practice there is no possibility of overstraining the plates or bursting any cloths, we have nothing to fear, and therefore should not mind if the pressure ran up to 150 lb. even. In point of fact each press has been actually tested at 200 lb. to the square inch, without sustaining the slightest damage. I think, also, you have seen no *blow*, and the condition of the room, after fifteen months' working, will show you we have not been troubled on that score. When there has been an occasional blow—and all presses are liable to them—it has been so slight that it has never extended beyond a few inches from the press.

Returning to Maidstone, the following speeches were made:—

The PRESIDENT: Mr. Mayor: It may have appeared that some of our remarks on the paper read by your esteemed surveyor, were a little stringent, but I believe that if we had had the opportunity of seeing the works before we criticised them, our observations would have taken a very different turn. I am pleased to say, after seeing the position of the works, the difficulties of the site, the nature and character of the Medway—which I had not seen before—that I have no hesitation in telling you that under the circumstances in which you are placed you need have no fear whatever of succeeding entirely and completely with the lime process at your proposed tanks. The theory of land filtration in addition to any chemical process, is one which I endorse to the extent it was indulged in this morning under certain given circumstances, but those circumstances are not present in Maidstone, and therefore I fully endorse the plans Mr. May has proposed to you. It is only right and fair I should say this much after the criticisms passed this morning.

Mr. JONES: I believe when we met this morning we did so under considerable disadvantage—we met in fact before we had had time to consider thoroughly the details presented to us, and without a knowledge really of what we were criticising; we had a general idea of something or other, but we did not know exactly what it was; but subsequently we were permitted to see the works, and I must say we then came to a conclusion somewhat different to that we arrived at in the earlier part of the day; and personally I must bear my testimony to this simple fact, that Mr. May, your officer, has done and is doing his duty to the fullest possible extent. As an expert in the lime process, I must say I never saw a set of plans or works proposed for carrying out that process, which were more thoroughly well thought out than the plans placed before you by your engineer, Mr. May, and I feel I am bound to bear this testimony, as I should wish any one else to do if I were placed in similar circumstances. In so doing I am only saying that which we feel to be our honest conviction in connection with the various works placed before us this day; and I have no doubt that when we visit you some three or four years hence, when these various works have been carried out to their completion, you will be proud of the results you have achieved and fully satisfied that you have done that which is for the best interest of the ratepayers. I congratulate Mr. May on having produced a scheme which I believe will work out in the most successful, satisfactory, and economical manner, and to the benefit of the town at large.

During the day a visit was paid to the Sewage Outfall Works upon the Medway, where the new sludge presses and other machinery were inspected.

DISTRICT MEETING AT LINCOLN.

April 14th, 1888.

Held at the Guild Hall, Lincoln.

JOSEPH GORDON, *President, in the Chair.*

The MAYOR (THOS. MARTIN, Esq.) gave the members of the Association a cordial welcome to the ancient city of Lincoln, and expressed the hope that their visit might prove advantageous to them in carrying out their duties in their respective districts. He did not claim for the system of sewage disposal adopted at Lincoln that it was perfect, but he thought when they had visited the works they would agree with him that it was a very good system.

The PRESIDENT acknowledged the kindly expressions addressed to the members by his Worship, and said they were always delighted to have with them at their meetings the chief magistrate of the town or city which they visited. He expressed the hope that his Worship would be pleased to remain and hear the discussion which would take place upon the papers that were to be read.

Alderman MALTBY, as late chairman of the Special Sewerage Committee, also welcomed the Association to Lincoln.

The PRESIDENT then proposed the re-election of Mr. E. Buckham as the District Honorary Secretary. Mr. Buckham had filled that office for some time, and had discharged his duties in a very able and energetic manner.

Mr. J. W. COCKRILL (Great Yarmouth) seconded the proposition, which was carried unanimously.

The minutes of the last meeting of the district, held at Great Yarmouth on the 5th of June, 1886, were read and confirmed.

NOTES ON LINCOLN SEWERAGE WORKS, WITH SPECIAL REFERENCE TO THE FILTER-PRESSING MACHINERY.

By R. A. MACBRAIR, Assoc. M. Inst. C.E., Lincoln.

Like many other towns Lincoln hesitated a long time before it embarked on a sewerage system. Just forty years ago—in 1848—the late Mr. George Giles, M.I.C.E., was asked to report on the "existing state of drainage," and to furnish an "estimate of cost of carrying out a system of underground sewerage." As might be expected, he found a somewhat deplorable state of things—at least judged from our *present* sanitary standpoint. Yard surface water, house drainage—where not left to stagnate—drains from closet cesspools, &c., generally found their way into the street channels, *en route* for the river. In the northern part of the city, on the hill-side, the Oolite formation absorbed the sewage put thereon, but this being stopped in its downward course by the Lias formation, had a great tendency to pollute the drinking wells. Again, in the lower part of the city the land is only a few feet above the level of the river Witham, consequently the liquid in the cesspools did not readily flow away, thus polluting the wells which formed the main water supply. Both on the hill-side and the flat, the water had a well-known fœtid smell.

It might here be stated that a private company obtained in 1846 an Act for the Construction of Waterworks, and in 1849 were supplying 110,000 gallons to 733 houses.

At this time—1849—the estimated population was 16,500, the number of houses 3693 (4·48 persons per house), and the death-rate 24 per 1000.

Mr. Giles, M.I.C.E., recommended separate systems for surface drainage and sewage, a pumping station, lime precipitating tanks, &c., at an estimated cost of 29,388*l*.

This report was duly considered, talked about in board-room and city, and—nothing done. We must remember that forty years ago, the absolute necessity of a sewerage system for the sanitary well-being of a community was not universally acknowledged, or at least there was a general opinion that a sewerage system was not a good and fair equivalent for a good round sum of money and a dreadful consequent increase in the rates! A faithful few still clamoured for sewerage, but the matter lay practically in abeyance till 1866, when the Local Board was established here. In that year the late Mr. Tarbotton of Nottingham, the late Mr. Lawson of Westminster, and Mr. M. Drury, the local surveyor, were asked to send in sewerage schemes. These were designed, received and considered, but the Local Board being of opinion that "the highest scientific authorities are at issue as to the mode of getting rid of and utilising town sewage," resolved, with but one dissentient, to again postpone the matter. In 1870 a memorial was sent up to the Secretary of State, complaining that the Local Board were in default in providing a proper system of main sewerage.

A copy of this report being sent to the Local Board, they in reply stated that they had made arrangement with the Great Northern Railway Company to flush the Foss Dyke and Witham, two streams forming the chief outlet for the majority of the water-closets and the house drainage. This was deemed unsatisfactory. Mr. Arnold Taylor, Government inspector, held an inquiry in October 1870. In his report to the Secretary of State he stated that the Lincoln Local Board had certainly failed in their duty (in this respect), and recommended "that three months be granted to the Board to decide upon the course they propose to pursue with respect to the drainage." Lincoln is not the only town that has been favoured with such missives, or gentle reminders of their duties. The Lincoln Board at last made up their mind to carry out the works required, and having so determined, no one can find fault with the thorough manner in which it has been done.

The plans of Messrs. Lawson and Mansergh were accepted, the provisional order obtained, and tenders advertised for in 1876. The work was commenced in 1877, and finished, with the exception of laying-out farm, in 1880. The works done were as follows:—

Three miles of brick sewers, the largest being the reservoir next the pumping station, 9 feet high, 9 feet wide, tunnel-shaped, the others being egg-shaped, and ranging from 3 feet 6 inches by 2 feet 4 inches to 2 feet 6 inches by 1 foot 8 inches, and twenty-six miles of pipe sewers, ranging from 24 inches to 9 inches—all being Stanford's patent joints—21 miles of sewers were laid in waterlogged ground. The usual manholes and ventilators were built at alterations of line and gradient.

About one-tenth of the volume of sewage is carried under the river Witham by an inverted syphon 2100 yards in length, constructed of 24 inch cast-iron pipes. From the pumping station the sewage is carried to the farm by a 20 inch cast-iron rising main about 1500 yards in length.

The pumps consist of a pair of compound condensing engines, fitted with Davey's patent automatic differential gear, actuating four ram pumps, diameter 22 inches, one under each cylinder (sizes of which are, high pressure 15 inches, low pressure 30 inches), and three cylindrical two-flued boilers, adapted to work at a pressure of 80 lb. per square inch. Ordinary working speed, 14 strokes per minute, and length of stroke 5 feet. Allowing for slip, 145 gallons are pumped per stroke, capacity of pumps being 160 gallons. The bottom of suction well is 23 feet below engine-house floor, and the total lift about 70 feet.

The daily quantity of sewage pumped is 900,000 gallons in dry weather, rising to 1,500,000 or more after heavy rain. In many of the yards to the houses the surface water flows into the gullies, thereby increasing greatly the quantity of sewage, diluted though it may be. On the farm are four large precipitating tanks, holding about 210,000 gallons each, and two smaller ones of 54,000 each. Part of the sewage turned a wheel actuating a mortar mill for grinding and mixing the lime, but, as will be explained shortly, advantage has been taken to provide on the filter-pressing premises machinery for mixing and forcing the lime into the rising main before it reaches the tanks. The farm consists of 68 acres (60 acres cultivated) of land well suited for the purpose—sand being met with about a foot under the surface.

The following is an abstract of the cost of the works:

	£
29 miles of brick and pipe sewers, manholes, river crossings, &c.	75,245
Cast-iron syphon and rising main	5,339
Pumping station complete, and two cottages	6,696
Precipitating tanks	4,550
The farm now irrigated; (40 acres); (we rent 28 acres from the Corporation in its municipal capacity, at 2*l.* per acre	5,426
Laying out farm	6,102
Pumping machinery	5,230
Heighington farm, let by Corporation (206 acres) ..	11,025
	£119,613

This is exclusive of cost of various late extensions of works, compensations, legal expenses, &c. Total cost of sewage works of every description is about 136,000*l.*

It may be interesting to state that the loss on working the farm, exclusive of all rent, taxes, &c., has averaged 230*l.* a year; this includes the manager's salary. In 1883, the first whole year of working, the loss was 397*l.*; in 1887, 190*l.*; the loss is therefore gradually being reduced. The farm, being on an incline (the fall from south to north being about 40 feet), was converted into small terraces, necessitating thereby much hand labour. At the top of the batters we have lately put fruit-trees—apples, pears, plums, gooseberries, currants, &c.; though but young, nevertheless they have borne some exceeding fine fruit, and promise to yield a fair revenue.

The following statistics may here, perhaps, be usefully inserted:—

Acreage of city, 3891 acres.
Rateable value of property, 150,000*l.*
Death-rate for 1887, 16·4 per 1000; exclusive of public institutions, 14·2.

	Population.	Decennial increase per cent.
1801	7,197	
1811	8,597	19·4
1821	9,995	16·2
1831	11,217	12·2
1841	13,896	23·9
1851	17,536	26·2
1861	20,995	19·8
1871	26,766	27·5
1881	37,312	39·4

Estimated population in middle of 1888 44,953
Present number of houses, 9132.
„ „ W.C.'s, 2934, including 100 in public institutions.

The following average quinquennial death-rate for the last twenty years may be interesting, especially when it is remembered that the sewerage works were finished in 1881, in which year the house connections were commenced.[*] The last quinquennial period (since 1881) shows a great drop.

	Death-rate per 1000.	Death-rate, exclusive of public institutions.
1867 to 1871	22·9	20·1
1872 to 1876	23·9	21·1
1877 to 1881	23·0	20·3
* 1882 to 1886	19·7	17·2
1887	16·4	14·2
1848	24·0	

In 1885 the Corporation determined to undertake further works on account of the effluvia arising from the farm, the sewage at that time being passed on the land in its crude state, i. e. unprecipitated. They therefore asked Mr. Mansergh, C.E., to report on the matter. In an exhaustive report, comparing the advantages of precipitation and broad irrigation as affecting our particular circumstances, he recommended the carrying of the sewage several miles further out of the city to Heighington (by the extension of the rising main) and the purchase of more land to add to the farm already in the possession of the Board, in fact purchased years ago in contemplation of such a contingency. The capital outlay of these works was estimated at 33,000*l.*, and the additional annual working cost at 1537*l.* In these times of somewhat depressed trade, the Corporation felt unwilling to incur such a large expense, though persuaded that the scheme was a good one. Anxious to tide over the next few years in hope of better times, they asked me to recommend some temporary expedient. After inspecting various sewage works in the country, I recommended (May, 1886) that the sewage should be treated with lime and sulphate of alumina, and the sludge pressed by filter presses. In the following September we began using lime (alone), but as several members of the committee thought they should like to see the action of the filter presses for themselves, it was not till the following May, 1887, that my report was accepted and the works I had recommended a year previously ordered to be carried out. I have seen and carefully noted the work done by presses made by the following firms: S. H. Johnson & Co.; Drake & Muirhead; Manlove, Alliott, Fryer & Co. I had recommended the employment of 10 cwt. of lime and 7 cwt. of sulphate of alumina per million gallons, and the erection of filter presses as patented by Messrs. Manlove, Alliott, Fryer & Co., of Nottingham. The capital cost I put at about 2600*l.*, and the annual expense at 700*l.*, exclusive of any credit for "cake" sold.

Thinking it might be useful, I have annexed the tabular statement accompanying my report of May, 1886, as it shows the chemicals used, the cost of treatment and filter pressing, &c., in various towns.

Before recommending Manlove, Alliott, Fryer & Co.'s type of filter presses, the advantages of air compression as compared with direct acting pumps were considered. But in a paper which only professes to be "Notes on Lincoln Sewerage," this is a question too large to be now adequately discussed. In the old type of presses, the blocking of the pump valves has always been the *bête noir*. Messrs. Drake and Muirhead, in their Maidstone presses, claim to have overcome the difficulties seemingly inherent in sludge *pumping* presses. Of course it is admitted that in pneumatic presses there is a loss of power roughly estimated at about one-third. Nevertheless it is a moot point whether pneumatic are not preferable to pumping presses when the grinding action of the pumps, the various stoppages, hammering of valves, and the slow speed of working are taken into account. Some of the advantages claimed for Messrs. Manlove, Alliott, Fryer & Co.'s presses are, the use of air cylinders for closing up the ends (thereby saving labour), the great stiffness afforded by their construction, the square plates economising cloth (as a greater area of filter surface can be covered with the same roll of cloth), the larger size of central opening for passage of sludge (making a longer press possible), the re-use of a portion of

Fig. 1.

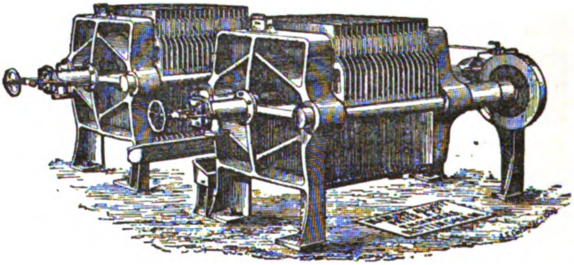
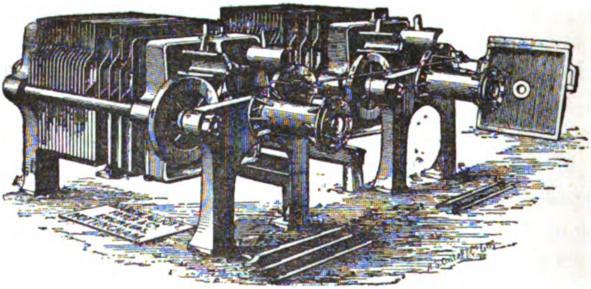


Fig 2.



the compressed air, tightening both end nuts by downward pressure, &c., &c.

Our Filter Press Works consist of the following buildings:—

	'	"		'	"
Boiler-house	30	6	×	17	0
Press-house	44	4	×	26	3
"Cake" store	36	0	×	17	0
Mixing house	42	0	×	9	0
Workshop	9	6	×	9	0
Sludge reservoir	55	6	×	8	3

(under latter two rooms) capacity about 21,000 galls.

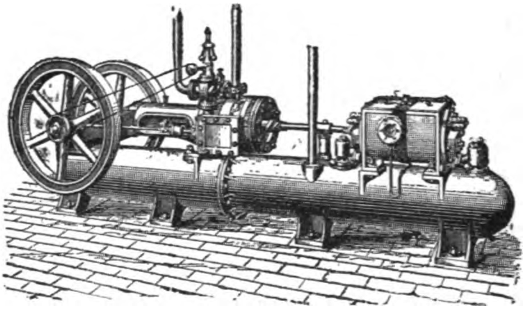
Though the two presses will easily suffice for our requirements for several years to come, yet the press-house has been built large enough to accommodate another press, the two present rams will work three presses; the machinery also has been arranged to run another press when required. The "cake" store is only of such a size as will suffice for our daily make. To construct a large store of the same character as our present buildings would be waste, something less substantial and costly being sufficient. I am about to erect a corrugated iron shed to be placed at the west of the present buildings, connected by tram rails; also two cottages, for engine-driver and stoker. As will be seen on inspection, the works are on a hill-side. Advantage has been taken of this fact in several ways. Instead of pumping the sludge into rams, as is usually done, it flows out of reservoir into the rams by gravitation, again, the water for the boiler and for cooling the air-compressing cylinder, has been brought from the hill above in 2-inch iron pipes, and, lastly, a loading dock for filling carts with sludge has been constructed, with a low-level road, the main carriage road being carried over by a bridge. To allow of the sludge flowing into rams, these had to be sunk rather low; the height from bottom of concrete foundation to level of platform floor of press-house is 25 feet. The foundation is on boiling or running sand, water evidently flowing out of the hill over an impervious stratum. To get in the foundations was a matter of some difficulty, pumping being carried on night and day for several weeks. The ram chambers are literally in a bath of water 14 feet high, a drain was placed at this level (as low as our outlet would permit of) to relieve the pressure.

The machinery consists of the following:—

Two 30-celled patent improved sludge presses.

One improved double-acting air-compresser, 9 inches by 12 inches, driven by direct-acting steam-engine, 10 horse-power, having cylinder 10 inches diameter, 12 inches stroke, the whole mounted on extra large and strong cylindrical cast-iron receiver; one Cornish boiler, 5 feet diameter, 16 feet long; one exhaust steam injector; one wall donkey pump; two vertical sludge rams, 4 feet diameter, 12 feet deep, with necessary inlet and outlet valves; and one water tank, holding 600 gallons; one cast-iron mixer, 3 feet diameter, 4 feet deep; one lime elevator; one ram for forcing lime into rising main, and one 2 horse-power vertical engine for driving same.

FIG. 3.



The rams and air-compressor were tested up to 200 lb. pressure.

The following is the probable cost of the works (they are not quite finished):—

	£
Buildings	1225
Filter-pressing machinery, including lime-mixer	1475
Formation of roads, levelling of terraces, &c.	200
	£2900

Additional buildings and machinery have been erected beyond those originally intended.

Though a few tons of "cake" have been pressed, the machinery cannot yet be said to be in ordinary working order. When inspecting the works this afternoon one press will contain "cake" ready to be removed, and the other press will be empty ready for filling. Very good cakes are being produced, and the process promises to be quite a success. A press will make 19 cwt. of cake each time of charging. We are using about 90 lb. of lime per press and compressed air at 90 lb. pressure, the steam gauge standing at 45 or 50 lb.

In the lime-mixer for precipitating, we use 15 cwt. per million gallons. I have tried half a ton of aluminoferric, made by Messrs. Peter Spence & Sons, Manchester, but on account of the large quantity of sludge now in precipitating tanks, the article has not had a fair trial. When this sludge is worked off into "cake" I shall again try the aluminoferric. Formerly we used to run out the sludge into open earth tanks, which sometimes gave off terrible effluvia at certain seasons of the year. During the erection of the works we interfered with the open tanks and thus accumulated the 2500 tons of sludge now on hand. We are commencing to sell the cake at 3*s.* per one horse load (we hope to make more); at present we have no weighing machine on the premises, though one will shortly be put down. When in full working order we expect to get sixteen presses a day, pressing 15 tons of cake. Our sewage will yield most likely about 60 tons of cake weekly, more or less. From returns in my possession I find it impossible to dogmatise on this point. Some people state that two tons of cake per week per thousand of population treated is a fair average, but this is by no means universally borne out by facts, and is, I think, too much. Six days' pressing per week, working ordinary hours, will therefore easily do our work.

The following is the probable annual cost of working, including lime-precipitating as well as filter-pressing:—

Daily flow of sewage taken at 1,000,000 gallons.

	Annual Cost.		
Lime, 15 cwt. × 365 days = 274 tons @ 9*s.* 9*d.* ..	£133	11	6
Lime for 2 presses, 15 cwt. × 312 days (12 charges) 234 tons @ 9*s.* 9*d.*	114	1	6
Cloths for 2 presses say	35	0	0
Coal, 5 cwt. per day × 312 days = 78 tons @ 8*s.* 8*d.* ..	33	16	0
Labour: 1 man 27*s.*, 1 man 23*s.*, 1 man 21*s.*, youth 13*s.*	218	8	0
Repairs, say	40	0	0
Insurance, oil, and sundries, say..	35	0	0
	£609	17	0

As will be seen, no credit is taken for any sale of cake. Eliminating as far as may be, though it is impossible to do it with perfect accuracy, from the above the cost of lime precipitating, it a that the probable cost of cake pressed—taking working ex only into account—will be from 2*s.* to 2*s.* 3*d.* per ton.

I regret that press of work has not permitted me to give more exhaustive paper—one more satisfactory to this Di Meeting and to myself.

Cake prod weekly
Non
No
Nc
35
4
Al

Filter Presses.			Total annual Net Working Cost of sewage treatment per Head of Population.
Cake produced weekly.	Price sold at per ton.	Yearly cost of Pressing per head.	
None	None	None	4½*d.*
None	None	None	6¼*d.*
None	None	None	11*d.*
350 tons	Given away	3*d.*	6*d.*
46½ tons	1/–	3¼*d.*	5¼*d.*
Not in full	working order	4½*d.*	5¼*d.* taken at 12,500 population
About 90 tons	from 1/– to 2/6	3*d.*	Information not supplied
19 tons	4/–	About 2*d.*	5¼*d.*
100 tons	Have to pay for removal	2¾*d.*	9*d.*
50 tons	Given away	6¼*d.*	* * 2/-

R. A. MACBRAIR.

SEWERAGE, WATERWORKS, AND BRIDGE CONSTRUCTION AT KING'S LYNN.

By E. G. MAWBEY, Assoc. M. Inst. C.E., City Surveyor, York.

Sewerage.

The author designed a scheme to collect the whole of the sewage of the borough, and to convey it to one outfall at a distance of about three-quarters of a mile below the town.

Several years before the author was appointed, Mr. W. H. Wheeler, M. Inst. C.E., of Boston, designed and carried out a scheme of sewerage sufficient for about one-third of the built area of the town, with its outfall into an existing sewer, 6 feet diameter, at the northern or lower end of the town, belonging to the Dock Company, which sewer was previously laid to form the outfall for the drainage of a large area of agricultural land. Mr. Wheeler then suggested the necessity for an outfall at some considerable distance below the town.

The sewers constructed in the past, with the exception of those designed by Mr. Wheeler, were laid upon no general system. There were no less than 28 sewer outfalls, and about 111 private drain outlets, into the Harbour, the Fleets, and the River Nar, falling in as many different directions, and even up to the time when the author was appointed new sewers were being laid which could not be adopted as part of any proper system.

The author therefore advised that a scheme of sewerage be designed and adopted for the whole of the borough, so that, as far as practicable, whatever new sewerage it might be absolutely necessary to provide should be so laid down and constructed that it would eventually form part of a general scheme for the whole town, and thereby effect a great saving.

The author's recommendation was adopted by the Corporation, and subsequently about 2540 lineal yards of new public sewers were laid, besides new drains to nearly all the houses abutting thereon, as well as somewhat extensive schemes of new drainage for the Lynn Union Workhouse and the West Norfolk and Lynn Hospital, designed and carried out by the author, to work into the general scheme which he has now to explain to you.

The Port of Lynn is situated on the estuary of the Ouse, discharging into the Wash.

The ordinary spring-tides rise and fall about 21 feet, and the minimum rise and fall of neap tides is about 12 feet.

The usually highest spring tides rise and fall about 23 to 24 feet, and the highest exceptional spring tides about 25 feet.

The heights of the tides in reference to Ordnance datum are—

High water of ordinary spring tides 13·4, and of neap tides 6·7 above Ordnance datum.

Low water of ordinary spring tides is about 7·7, and of neap tides about 5·3 below Ordnance datum.

The levels of the surfaces of the streets and roads of the inhabited portion of the borough vary from a minimum of only about 11 feet to a maximum of only about 21 above Ordnance datum, and the levels of the surfaces at the upper ends or farthest reach of the sewers, where the sewers must necessarily be the highest, are invariably the lowest, whilst those parts of the town lying nearest to the river and harbour vary from 17 feet to 21 feet above Ordnance datum.

It will therefore be seen that a considerable portion of the borough lies much below, and that none of the streets are more than about 4·6 above the usually highest spring tides.

With such an extremely flat and low-lying town, with no possibility of dividing it into zones with high and low-level outfalls, it is manifestly somewhat difficult to design a scheme for carrying the whole of the sewage to one outfall away from the town, which shall provide amply for rainfall and storage, and with such gradients and flushing arrangements as will keep the sewers fairly free from deposit without having recourse to pumping.

The population of the municipal borough and of the village of Gaywood, whose sewage runs into the Lynn sewers, was in 1881 about 19,090.

The increase of the population of Lynn for the ten years from 1871 to 1881 was about ·6 per cent. per annum, and taking the increase for the last six years at the same rate, the present population of Lynn and Gaywood would be about 19,800. Assuming that the probable future increase will be about 1½ per cent. per annum, the population of Lynn and Gaywood in thirty years hence, if that rate of increase was maintained, would be about 30,000, and this the author thought sufficient to provide for.

The total area of the municipal borough as extended by the King's Lynn Corporation Act 1880, is 3100 acres.

The area at present built upon in Lynn and in the village of Gaywood, and now drained by covered sewers, is about 460 acres; there are about an average of 43 persons to the acre for the area built upon.

The author allowed for the probable extended area built upon at the same rate of increase as allowed for the population (viz. about 1½ per cent. per annum), making the estimated area built upon and drained into covered sewers in thirty years hence about 700 acres.

In calculating for the main sewers a population of 30,000 and a drainage area of 700 acres was therefore provided for.

The system of sewers is, however, so arranged as to form a basis for further extension.

The probable future extended building area is apportioned to each district as it seemed to the author likely to grow, and the capacities of the sewers are determined accordingly.

The mean rainfall per annum for the twenty-one years 1866–1886 has been 27·79 inches, and for the ten years 1877–1886 29·55 inches.

In the wettest year (1872) 37·26 inches fell, and in the driest year (1874), 20·17 inches.

During the last ten years the average number of days in a year when ½ inch and less than 1 inch fell within the twenty-four hours was 8·6, being eighty-six times in ten years.

When 1 inch and less than 1½ inches fell, 1·8 days, being eighteen times in ten years.

When 1½ inches and less than 2 inches fell, 0·2 days, being twice in ten years.

And when 2 inches or over fell, 0·1 day, or once in ten years.

But in August 1872 there fell in one night 3·75 inches.

Allowing 30 gallons of sewage per head per day, when the present waste is stopped as after mentioned, including infiltration through the sewers, the daily flow from a population of 30,000 would be 900,000 gallons, and a mean flow of 625 gallons or 100 cubic feet per minute.

The maximum discharge of sewage proper during the day may, however, be taken at 200 cubic feet per minute.

Two inches of rainfall per day, or twenty-four hours, on 700 acres amounts to 31,710,000 gallons, and is equal to 22,021 gallons or 3529 cubic feet per minute.

The quantity of sewage is, however, so small compared to the rainfall which must be provided for (being only about one-seventeenth of its volume), that in speaking of the capacity of the sewers the author refers to the rainfall only.

To give a fair idea without complicated minuteness of the efficiency of the proposed sewers, roughly speaking, it may be said—

1. That the whole of a 2-inch rainfall over 700 acres amounts to about 32,000,000 gallons.

2. That the main outfall will be completely tide-locked twice a day for an average period of about six hours each tide.

3. That in an exceedingly flat town like Lynn, and with so many macadamised streets and roads, and allowing for absorption and evaporation, on very rare occasions, if ever it does happen, that more than a volume equal to half the rainfall on the whole area reaches the outfall sewer.

4. Allowing for half of a 2-inch rainfall in twenty-four hours to reach the sewers, if the outfall was never tide-locked, a discharging capacity at the rate of 16,000,000 gallons only in twenty-four hours would be required.

5. But as the outfall will be completely closed about half the time, and that consequently when it first becomes open the sewers will at times during heavy rain be required not only to discharge the water coming in, say, at the estimated rate of 16 million gallons in 24 hours, but also at the same time the volume which has accumulated and has been stored in the tank sewer during the tide-locked period, and considering that for short periods the downpour is frequently much greater than at the rate of 2 inches in 24 hours, and also to provide amply for the storage of the estimated ultimate volume of sewage considerably diluted before bringing the storm outlets into play, the author found it necessary in his calculations to provide for the sewers to discharge when running full and the outfall free from obstruction, independent of the aid of the storm outlets, a volume of storm water and sewage combined equal to the rate of the flow of the whole of a rainfall of 2 inches in 24 hours from the area (viz. 700 acres) estimated to be built upon in 30 years hence.

Respecting storage capacity, allowing for one half of a rainfall at the rate of 2 inches in 24 hours to reach the sewers, the volume which would flow in during a tide-locked period of six hours from 700 acres would be nearly 4 million gallons, and from the 460 acres at present built upon rather less than 3 million gallons.

Now the storage capacity of the main outfall sewer and storm outlet sewers proposed is rather less than 2,000,000 gallons, therefore taking this view of the question they are not too large; they may seem too small, but in reality they are not so, because, in the event of the continuance of a heavy downpour after the sewers were full they would soon be relieved by the storm outlets.

When Mr. Wheeler's scheme was submitted to the Local Government Board it was agreed that in consequence of the facilities afforded by the great rise and fall of the tide, pumping power might be dispensed with, and the author therefore found it necessary to fall in with that decision.

He, however, mentioned in his report that pumping would be infinitely better than providing storage capacity.

The separate system is not adopted because of the facility available for getting rid of the crude sewage at once without fear of causing a nuisance, and having regard to the fact that no profit would be likely to accrue from the utilisation of the sewage for its manurial value, especially as it would have to be raised for treatment by pumping power.

Because of the narrowness of the streets, the very treacherous nature of the subsoil throughout the borough, and the consequent liability to serious damage to property from subsidence, and also to avoid as far as practicable the great expense and risk involved in very deep and large sewers, the author divided the system into a number of small drainage districts, each district being drained by a set of comparatively small sewers, of sufficient capacity only to carry off the sewage and rainfall from their own district, and laid no deeper than necessary to drain cellars, the trunk sewer of each district being intercepted by a deep main intercepting sewer.

The sewers at or near the head of each district are, where practicable, also connected with the main intercepting sewer, by which means in some districts the sewage from the main sewer may be diverted for flushing the tributary sewers, and in the event of a temporary block in the main intercepting sewer, the sewage would, after rising to a certain height, flow safely round the district and back into the main sewer, such connections at the same time improving the ventilation.

The whole of the sewers are designed to be laid in straight lines and uniform gradients from point to point, with manholes as inspection and ventilation shafts about 60 to 70 yards apart, and the manholes circular wherever practicable.

In the districts where portions of the scheme have already been carried out (the old sewers being taken up), and also new house-drains laid wherever efficient glazed pipe drains did not exist, disconnecting traps have not been placed on the house-drains leading to the sewers, excepting where the drain passed under a house, but a 4-inch extracting shaft has been fixed at or near the head of every drain, proper means of disconnection with the interior of the houses have been adopted, and all sewage inlets properly trapped. Wherever in excavating for the new sewers the old sewers had to be removed, the old house-drains were temporarily connected with the new sewers.

Now, as to the system of ventilation of sewers adopted, it was found that before the new house-drains with their ventilating pipes were laid, although the flushing arrangements were in work, very unpleasant smells emanated from the street surface ventilators, but, with very few exceptions, such smells have not been felt since the new house-drains with their ventilating pipes have been laid and connected.

The exceptions are,—

Two cases each at the dead ends of short branch sewers. In these cases the proposed hydrants for flushing had not been fixed and there was a deposit in the sewers; subsequently the hydrants were put down and used, and there have been no complaints since.

In two other cases the manholes were in close proximity to the old defective sewers which were daily back-watered by tidal influence.

Speaking further on ventilation, the two completely new systems of drainage before mentioned, designed by the author for the Lynn Union Workhouse and the West Norfolk and Lynn Hospital, were provided with surface ventilating manhole covers at nearly every inspection shaft, even in places where many persons pass over daily. These surface ventilators were, however, supplemented by 4-inch by 6-inch vertical shafts carried above the roofs of the respective buildings and each provided with an induced current ventilator called the "Climax."

The author made many personal inspections and inquiries of these open-surface ventilators when residing in Lynn, and only a few weeks ago further inquiries were made respecting them by Mr. Silcock, with the result that at no time has any nuisance been experienced.

The author must, however, also mention, that practically every part of each of these systems is flushed by automatic syphon flushing tanks, either in special chambers at the head of the drain, or in connection with trough closets, which syphons and syphon tanks were supplied by Messrs. Adams & Co. of York and London.

The new sewers required to complete the whole system is 3 miles 216 yards of brick sewers, and 9 miles 1 furlong 91 yards of pipe sewers, making altogether in the whole scheme, exclusive of the dock culverts, old sewers utilized as storm outlets, and the pipe sewers in private streets, a length of 4 miles 3 furlongs 132 yards of brick sewers, and 10 miles 6 furlongs 120 yards of pipe sewers, and a total of 15 miles 2 furlongs 32 yards.

In order to make the periods during which the main outlet is free from tidal obstruction as long as possible, the author kept its inverts up as high as the levels of the town will admit of, even at the expense of the gradient, depending on flushing rather than having it constantly backwatered.

Ample means of flushing are provided, as hereinafter set forth.

The level of the invert of the proposed outfall is about 6 inches above low-water neap tides, and about 2 feet 9 inches above low-water spring tides.

The storage capacity of the proposed main-trunk sewer is, as before-mentioned, nearly 2,000,000 gallons, or more than twice the whole quantity of the flow of sewage proper in 24 hours from a population of 30,000, allowing 30 gallons per head, and the sewers are capable of discharging (twice in 24 hours) about 2,000,000 gallons in less than 1½ hours when the outfall is quite free; but the discharge would commence as soon as the tide fell below the height that the sewage was dammed up in the sewers, and would continue for some time after the rising tide reached the invert, the duration of the discharge each tide varying in proportion to the quantity of rainfall reaching the sewers, being about six hours more or less.

The gradient of the circular brick outfall tank sewer is such as will give a velocity of rather over 2 feet per second when running half full or full, and of the oval brick sewers mostly such as will give a velocity of about 2 feet per second when running full, and rather more when running two-thirds full, and of the pipe sewers velocities of about 2½ feet to 3 feet per second when running half full or full.

There need be no fear as to deposit in the sewers if attended to, for the available flushing power is so great that there would be no difficulty in letting in sufficient water to obtain the above velocities at any moment when the tide is out.

The tank-sewer from the outfall is 6 feet in diameter, diminishing to 5 feet 6 inches diameter. The remaining brick sewers are egg-shaped.

A small outlying district is proposed to be provided with a gas engine for lifting the sewage into the main system.

Storm outlet sewers are provided to carry off from the main sewer of each district into the harbour or into the river Nar, as the case may be, at the nearest points the extraordinary flow of storm water during heavy rains.

The author has so arranged the location and levels that by putting in either of the storm outlet sewers for its particular district it would answer temporarily as an outfall for any of the new sewers proposed which it may be found absolutely necessary to lay before the whole scheme were carried out.

At the head of each district an automatic syphon flushing tank is to be constructed, supplied with a constant dribble of water from the mains by an efficient disconnecting arrangement.

The levels of the inverts at the junctions of the tributary sewers are so arranged that by means of flushing blocks fixed on the outlets (and balance valves on the inlets) the flow may be diverted so as to flush alternately most of the sewers of the district from the tank at the head of district, the supply being adjusted so that the tanks will be automatically discharged about low-water time.

Short branch sewers, which cannot be flushed by the district tank or tanks, are to be flushed with water, suddenly discharged from a manhole (in some cases where shallow the capacity being increased by a length of 21-inch or 24-inch pipes surrounded with concrete) provided with a flushing block, and also with a balance valve when not at the head of the sewer, the manhole being filled from a hydrant close by (purposely put down) by means of a stand pipe and short length of hose, and a flushing block fixed to the outlet of most of the manholes.

Means of flushing are provided where practicable from open water-courses, also by flushing gates fixed at proper intervals in the sewers at the manholes.

The whole scheme was estimated to cost about 40,000*l.*

Under the town and overlying the blue clay, at depths of about 13 feet to 22 feet below the raised street surfaces, but only about 6 feet to 8 feet below the surface of the naturally formed marsh outside the borough, and varying in its levels or elevations only about 5 feet, is a layer of peat, the remains of the forest, and overlying the peat are beds of loam (originally warp), black silt, shingle, &c., which have been deposited by the action of the sea before the area on which the town stands was reclaimed.

Over the loam, silt, &c., the surfaces of most of the inhabited parts of the borough have been raised about 5 feet more or less (in some places much more) with a "made soil" (now black), brick, rubbish, &c.

In consequence of the considerable vibration under even ordinary traffic in some parts of the town, the author, in taking levels, frequently found it very difficult to obtain accurate readings.

The whole of the soil above the peat is so loose and contains so much water, that the author found by experience with it, to avoid serious damage to the streets and buildings, sewer trenches had to be very efficiently timbered from the surface downwards, and the bulk of the timber has to be left in.

He has found that if even the first setting of timber at the top of the trench is removed, a fissure soon appears between the footway paving and the front walls of the adjoining buildings.

WATERWORKS.

On the 12th of October, 1883, only a few weeks after the author had been appointed Borough and Water Engineer and Surveyor, he was directed to prepare a scheme for providing a supply of wholesome water for the inhabitants of the town, the water at this time being so much polluted that handbills were circulated advising the public to boil and filter the water before use.

The author and his staff had to work day and night to get the scheme ready in time for application to Parliament, and on the 2nd of November the Council adopted the scheme and unanimously resolved that a Bill be promoted, and the Parliamentary plans were prepared and deposited.

At a public meeting, however, a majority of the ratepayers present, whilst approving of the scheme, voted against the outlay proposed, although it was shown that the annual saving in the working expenses in the new system and the saving effected by the stopping of the enormous waste would be nearly sufficient to repay the principal and interest; the ratepayers refused to abandon polluted for wholesome water, although they might have had it for next to nothing.

The water is derived from a stream called the Gaywood River, which rises at a place called Well Hall, at the outcrop of the chalk, at a distance of about seven miles, the water being at Lynn pumped without filtration direct into the mains, there being an open-topped stand-pipe about 106 feet high.

At present no proper provision exists for filtration, there being only two small beds, which simply act as strainers, and prevent extraneous matter from entering the mains.

Even when both these filters are working the water passes through at the rate of about 1 inch in depth per minute, instead of 4 inches per hour, as is required for good filtration.

This same channel which conveys the drinking water also acts as the main outfall drain for the sewage from a population of about 1800, and for the drainage of most of the farmyards within the watershed of the valley, and the impurities washed off of several thousand acres of land, such as manure, vegetable débris, and animal excreta.

The author has seen the sewage from public-house urinals, overflowing privy cesspools, house-sinks and slop-drains—including drains from the larger houses, where in some cases water-closets are in use—a number of farmyards with piggeries, stables, cattle-sheds, dung-pits, &c.—all flowing direct into the small tributary streams leading to the river.

Many common privies are built on the banks of these small streams.

The waterings where the cattle drink and stand in the water are also fruitful sources of pollution; but the worst case is the Grimston Churchyard, where there are some twenty-five bodies buried annually in the thin stratum of chalk, close to the outcrop, where one of the springs issues from under the churchyard.

During the dry weather the sewage and other contamination passes very slowly into the stream, as it stagnates and decomposes in the ditches, ponds, and farmyards until the rainfall carries it forward, when the colour alone of the water in the river is sufficient evidence of its character.

The effect of these causes of pollution is, of course, most perceptible in dry weather and after a long period of drought, when it becomes injurious because of the diminished volume of the springs.

At such a time the activity of vegetable and animal life, and of the various causes of decomposition and putrefaction are most rife, but the most dangerous state of the river under such conditions is when rain sets in and brings down the foul liquid which has been accumulating in the stagnant dykes and ponds.

The description of the sources of pollution might convey the idea to some that it would be hardly possible to use the water for drinking purposes, and such would be the case were it not for the purifying effect of oxidation.

It is doubtless totally unfit for domestic consumption, as has been frequently proved by analysis, but as neither the available dilution or oxidation would destroy germs of disease, in the event of a serious outbreak in either of the villages whose sewage indirectly reaches the river, the inhabitants of Lynn would obviously be in great danger, as has previously been the case, for in one instance an outbreak of dysentery in one of these villages was speedily followed by a similar outbreak in Lynn, and a like experience happened on another occasion, the result of an epidemic of typhoid fever.

The average death-rate has for the last few years been about 22, which is high for a town like Lynn.

With regard to the means of providing wholesome water, the author was of opinion that no practical amount of filtration would render the present supply safe and fit for domestic purposes, and therefore advised that the only satisfactory means of obtaining a supply of really wholesome water was to take it at once from the springs at Well Hall, where it issues from the chalk.

The quality of this water is undoubtedly excellent. By the analysis of Dr. Dupré it was found to be 18 degrees of hardness, and at another time, by that of Mr. William Johnstone, F.C.S., 17·6.

The outcrop of the chalk at or within a few feet of the surface extends a considerable distance, and in several places within a distance of about one mile the water flows out in considerable volume into the naturally formed water-courses.

The author took levels of these springs, and found that they varied only about 14 inches, the Well Hall spring (the chief source of the Gaywood River), which yields the greater quantity, being the lowest.

An abundant supply can be obtained wherever the outcrop is broken into, which can be amply augmented by adits or deep open trenches at sufficiently low levels.

In case there was any difficulty in arranging on reasonable terms for abstracting water from either of these defined channels without special parliamentary powers, it would have been only necessary to purchase by agreement a piece of land, including a length of the outcrop, and to sink wells, drive adits, or cut trenches, and lay perforated pipes to the pumping well.

The Well Hall springs alone yield a sufficient supply. The author gauged these springs when low, and found that they were discharging at the rate of 1,680,000 gallons in twenty-four hours. The supply might be readily increased if necessary by breaking into the chalk.

The level of the water at the springs is 31 feet above the average level of Lynn streets, and the surface of the water in the proposed service reservoir would have been 131 feet above the same, this being the greatest available height.

The pumping-station was proposed to be at the springs, the water to be forced up into a service-reservoir on the hill about three-quarters of a mile distant, and from thence to gravitate through a service main laid on the road side to Lynn.

It was proposed to lay a 15-inch main from the service reservoir to Lynn, which would discharge at the average level at which it would be drawn off fully 901,000 gallons in 12 hours, which, at 25 gallons per head, would supply a population of over 36,000, and this the author considered sufficient to provide for.

This maximum discharge in 12 hours would, however, be attended with the loss of pressure.

The rising main from the Well Hall springs to the service-reservoir, allowing a velocity of 3 feet per second, to deliver about the same quantity as the gravitating main was to be 18 inches in diameter.

The service-reservoir, designed to hold 750,000 gallons, was to be constructed of brickwork and Portland cement concrete and covered.

The author proposed two horizontal compound engines which, when both working, would be capable of raising 1300 gallons 100 feet high per minute, and working 70 hours a week would supply a population of 31,200, and working 84 hours a week an average of 12 hours a day would supply a population of 37,440. These two engines would then raise as much as the 15-inch main would discharge, without night pumping, excepting during the repairs, when one engine, working extra hours, would do the work.

One of these engines would, however, raise sufficient water for the present population.

The net horse-power required to raise the water, including the friction in the rising main, was about 43; two engines of 25 horse-power each, to allow a good margin, were therefore proposed.

There were to be two Cornish boilers, each 24 feet long and 6 feet in diameter.

The works, including a cottage, land, and engineering sundry expenses, were estimated to cost 30,000*l.*

On commencing duties at Lynn the author discovered that the water mains throughout the town were for flushing purposes, and for draining the mains during repairs connected with the old system of sewers 3-inch, 4-inch, and 5-inch branches were carried into the sewers. The obvious danger of this arrangement being that whenever the mains were empty, or nearly so, for repairs, &c., the partial vacuum in the mains caused a powerful incurrent which sucked in at a tremendous velocity the sewer air, and probably sewage, through any valves which might be slightly defective or left not securely turned off.

The author succeeded in getting these communications immediately cut off.

In 1884 the author drew up regulations for the prevention of waste, misuse, and contamination of the water which with some modifications were confirmed by the Local Government Board.

He also induced the Corporation to have a sample and testing-room provided, and no fittings of any description were allowed to be used until inspected and tested.

At this time the consumption was about 70 gallons per head per day, and the author strongly advised the Corporation to adopt and carry into effect a systematic means for stopping the waste, and ultimately in June 1886 obtained permission to operate upon one district.

He, however, first of all had a house-to-house inspection made, and a list prepared of the number of each description of fittings in every house in the borough.

A district comprising 106 houses and a population of 503, was then set out on a block plan upon which every house was shown to the $\frac{1}{500}$th scale.

The district was provided with a sluice-valve at each extremity by which it could be completely shut off. On each side of one of these sluice-valves a hydrant was fixed, and on every house-service pipe (under the footway), a Hayward Tyler's Southampton pattern square-headed stop-cock was fixed (in all 57), at the expense of the Corporation.

The hydrants also answered for fire-extinguishing purposes, street watering, &c.

The cost of the stop-cocks was as follows :—

	½ Inch.		⅝ Inch.		¾ Inch.	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*
Plumber's price for cock-soldered joints, labour, and fire	4	10	5	10	6	3
Examination and filling in and making good paving, &c.	5	0	5	0	5	0
Surface box for footway	1	3	1	3	1	3
	11	1	12	1	12	6

Instead of incurring the expense of a separate meter for each district, a Guest and Chrime's recording apparatus attached to their Siemen and Adamson's patent water-meter with clock arrangement was used, it being fixed between the two hydrants before mentioned, and attached to them by means of short lengths of hose fitted with ordinary screw couplings to the hydrants.

The quantity of water passing into the district is recorded on ribbon paper which passes at an uniform speed through a pair of rollers driven by the clock. The pencil which marks the diagram and denotes the number of gallons of water passing through the meter hourly is driven by the water-meter.

The total quantity of water passing during each test is also registered in the ordinary way by the dial of the meter.

The rollers revolve once an hour. At each revolution a dot is marked on the ribbon-paper indicating the hour. Each diagonal line of the pencil represents 500 gallons of water, and this is subdivided into 100 gallons by the horizontal lines on the ribbon-paper.

The quantity of water passing at any hour is therefore very clearly shown.

The author found this meter to work admirably.

To make sure that each service-pipe in use was supplied with a stop-cock, the whole of the stop-taps were closed, and then every tap in the district was tested.

The operation of detecting the waste was as follows:—

The meter was fixed at 6 p.m. (the sluice valve at the opposite end of the district being closed), and was removed at 6 p.m. the following day.

In this district, on the first testing, before any inspection of fittings had been made, the consumption per head per twenty-four hours was 42·24 gallons, and assuming that the least quantity of water which flowed into the district per hour during the night represented the waste, this quantity, multiplied by twenty-four hours, equalled a probable waste of 20·27 gallons per head per day.

Shortly afterwards an inspection was made, commencing at the first stop-cock at 2.25 a.m., and finishing at 4.45 a.m.

A Tylor & Son's patent bell waterphone was used, by which each stop-cock was stetheoscoped.

The stop-cock was first sounded when open and then when shut. Whenever a noise was heard, which ceased when the stop-cock was closed, the leakage was evidently on the house side.

If, however, the noise continued when the cock was closed, the waste was taking place on the water-main side of the cock, which might be either from the service-pipe, the main itself, or from some other service-pipe close by (which, however, was easily discovered), the observation being noted in an inspection book.

A day or two later, which should have been the following day, the premises only where a noise was heard were visited, the waterphone being again used.

Any small matter, such as putting a leather on a tap, was done by the inspector. In some cases no waste was detected, showing that a tap must have been left running. Where waste was detected, notice to repair fittings was at once served.

The result of the operation on this district was that without in any way restricting the legitimate use of the water, the consumption of a population of about 500 persons was reduced by the first application of the system to 16·70 gallons per head per day; and to effect this reduction, in ten cases only in this district were alterations or repairs to fittings required.

Below are specimens of the form of book used by the day and night inspectors, and also of the Waste Detection Ledger, but in the latter, on the opposite page, the diagrams were pasted.

During the time the author was at Lynn considerable extension and renewal of the water mains were carried out.

INSPECTION BOOK.

NAME OF DISTRICT. BOROUGH OF KING'S LYNN. LOCATION OF METER.

Date of Night Inspection.	Street or Situation.	No. of House.	Premises Supplied.	Owner.	Occupier.	Time Stop-Cock Shut.	Report.	Night Inspector.	Date of Day Inspection.	Report of Day Inspector.	If Repaired or Notice Served.	Day Inspector.

WASTE DETECTION LEDGER.

KING'S LYNN CORPORATION. WATER DEPARTMENT.

District.	Date of Diagram.	Hours of Testing.	No. of Houses.	Approximate Population.	Supply—Gallons.				Probable Waste.			Remarks.
					Day, 6 A.M. to 5.30 P.M.	Night, 6 P.M. to 5.30 A.M.	Per 24 Hours, or 23 Hours Pumping.	Per Head.	Minimum Supply per Hour during the Night.	Waste per 24 Hours or 23 Hours Pumping.	Waste per Head per Day, or 23 Hours Supply.	

In all cases before covering up, each length of pipes was tested by water pressure.

A great number of hydrants were also put down. These were supplied by the Glenfield Company, Kilmarnock, described in their catalogue as No. C. 28, and were found to answer admirably, although the cost was only about half that of the sluice-valve hydrants.

The author must, however, say that were the expenses not limited he would prefer the latter.

The author believes this work is being ably continued by his successor, Mr. E. J. Silcock, Assoc. M. Inst. C.E., the present Borough and Water Engineer and Surveyor.

IRON BRIDGE.

Over the tidal river Nar, at the point where it crosses the Wisbech main road, an iron highway bridge, designed and superintended by the author, has been constructed in lieu of an old wooden structure which crossed the stream at this place, and which from decay had become unsafe.

The author prepared two alternative designs, one for an iron lattice girder bridge of one span, resting on abutments of masonry and piling, estimated to cost 4100*l.*, and the other for an iron lattice girder bridge of one span, supported on four cast-iron cylinders, estimated to cost 3500*l.*

The design adopted was for a three-span wrought-iron lattice girder skew-bridge, with a waterway of 113 feet, two of the spans being 34 feet and one 45 feet.

The bridge is supported on 16-inch cast-iron screw-piles with flange joints, of which there are four rows.

On the piles are placed horizontal transverse wrought-iron girders 18 inches deep, and on these are laid six longitudinal plate girders 2 feet 6 inches deep, with top and bottom flanges 12 inches wide, 5 feet from centre to centre.

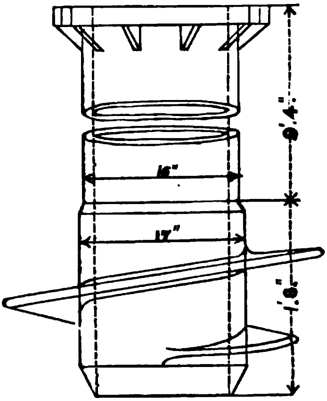
The floor of the bridge is formed of wrought-iron inverted $\frac{3}{8}$-inch curved plates, riveted on to the upper flanges of the longitudinal girders.

The longitudinal girders usually placed under each parapet of a bridge of this kind are dispensed with, the parapets being formed of wrought-iron lattice girders, which are made to carry half of the footway by riveting the floor plates to their lower flanges or booms.

The lattice girders rest on short cast-iron stanchions carried up from the top of the piles, and having bed-plates upon them.

Under these girders are light cast-iron arched ribs of ½-inch metal.

FIG. 4.



SCREW PILE.

At each end of the lattice-girder parapet are two cast-iron moulded pillars, each of which is surmounted by an ornamental lamp pillar with circular lantern.

At the narrowest part over the centre span the width of the carriage-way is 23 feet, with a 5 feet 3 inch footpath on each side.

At the approaches both the carriage-way and footpaths are wider.

The roadway consists of Portland cement concrete, of an average thickness of 9 inches, laid upon the curved iron plates, covered with granite macadam 4 inches thick.

The concrete work is also continued under the footways, which are formed of dressed and chamfered Mountsorrel granite kerbing (Mr. Gordon's Leicester pattern), and paved with Wilkinson & Son's Portland cement concrete flags, 2½ inches thick.

The earthwork under the approaches is retained by concrete walling.

The author's chief object in including this bridge in this paper is to give some particulars of the pile screwing, it being a kind of work not daily met with.

An abridged specification of this bridge was published in the *Contract Journal* of the 4th February, 1885, and it was more fully described and illustrated in the same journal, dated June 9th, 1886, but the following particulars have not been published.

The moving load was calculated at 200 lbs. per foot super, and the structure at 134 lbs. per foot super, making a total or working load of 3 cwts. per foot super.

This gives a good margin, but there are a great number of heavy traction engines pass over this bridge, and the possible maximum load by such was the basis taken.

Pile Screwing.

The piles were screwed by means of a cast-iron capstan 4 feet in diameter, with eight 6-inch by 6-inch hardwood radial bars 9 feet long, from centre of capstan to extremity.

The capstan was bolted to the upper flange of the pile. The top and bottom plates of the capstan were 1½ inches thick, and the divisions or sides of the radial bar sockets were 1 inch thick.

The bars were braced together at their extremities by chains.

In the end of each bar were two wedge-shaped grooves, into which two ropes were passed round the radial bars in opposite directions and attached to two ordinary double-purchase crabs.

The power required varied according to the nature of the strata and the depth of the pile from two men to each crab at single purchase to nearly the strength of four men at each crab at double purchase, but with this greater power both the radial bars and the piles occasionally broke.

In all five piles were broken, and each fracture occurred at a bolt-hole in the flange of the top length.

The old timber bridge was used as staging for the new iron bridge.

For each land-pile a hole some 5 to 8 feet deep was excavated. The pile was then placed in position and a rough framework of guide timbers fixed in the bottom of the hole.

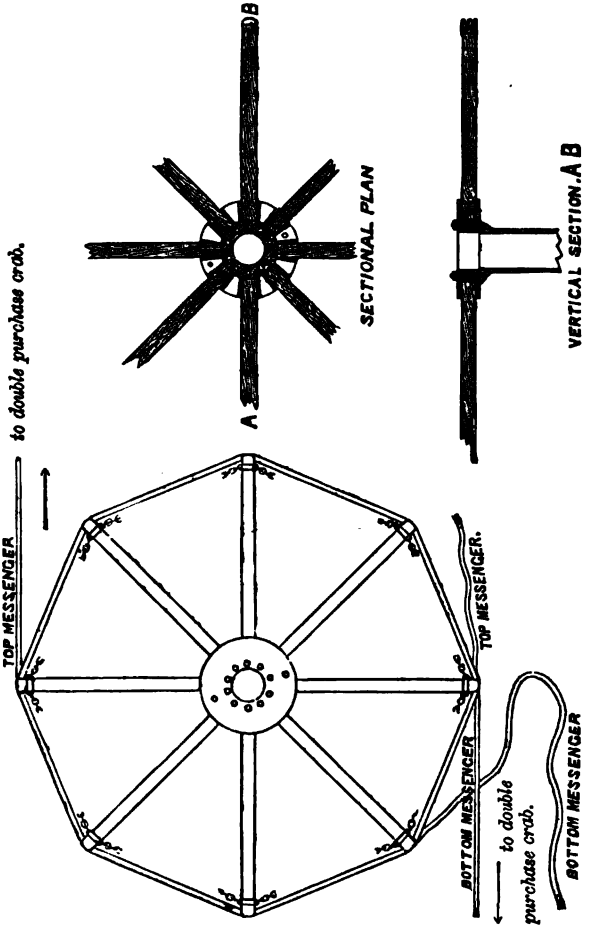
Another set of guide timbers was fixed around the pile at the stage level.

When the pile set was not at a convenient height above the staging for screwing, a short length specially cast for the purpose was used.

The piles in the stream were set within securely fixed guide timbers just above low water, where the piles were fixed, in addition to the guide timbers at the stage level.

Considerable difficulty was, in some cases, experienced in keeping the piles in position. In such cases they had to be occasionally screwed up and down several feet, and during this operation struts and wedges were used, and sometimes a chain so fixed round the new pile and secured to a pile of the old bridge that, as the new pile revolved the chain tightened and drew it into position.

FIG. 5.



CAPSTAN USED FOR SCREWING PILES AT NAB BRIDGE.

Another method adopted was to draw the pile in the direction required by means of a screw-shackle in a chain.

Some of the piles had to be weighted.

The following table gives particulars of the screwing:—

No. of Pile.	Length of Pile from Top of Cap.	Depth of Pile screwed through ground below bottom of Hole.	Depth of Core left in Pile when Screwed.	Number of Revolutions.	Depth screwed per Revolution.	Time Screwing per Revolution.	Number of Days Working at Pile.
	feet	feet	feet		inches	minutes	
1	38·00	28·67	10·17	30	2¾ to 7	5 to 35	3
2	35·00	25·50	5·50	56	¼ „ 8⅛	7 „ 30	6
3	35·00	24·50	7·75	45	1¾ „ 7	6 „ 21	4
4	35·00	19·58	7·83	30	3½ „ 7	5½ „ 16	3
5	37·38	20·36	9·78	17	6½ „ 8	4½ „ 22	2
6	37·00	18.25	7·50	26	6 „ 8	6½ „ 22½	4
7	34·06	15·31	7·56	14	5½ „ 7½	7 „ 44	2
8	37·00	19·75	13·00	28½	2¼ „ 8¾	5 „ 25	3
9	37·00	22·21	12·21	27½	3½ „ 8¼	5 „ 45	4
10	33·86	17·82	..	..	..	..	..
11	34·82	16·82	4·57	14½	3¼ „ 8½	10 „ 71½	2
12	37·00	20·00	3·75	21	4 „ 8½	2½ „ 85	3
13	22·03	13·03	5·36	13½	2½ „ 7	16 „ 41½	2
14	20·95	12·37	3·70	38½	⅛ „ 7½	7 „ 43	3
15	20·89	12·31	3·06	22	2½ „ 6	5 „ 48	2
16	21·00	13·00	3·75	17	3 „ 6	8½ „ 39	2
17	21·10	12·10	4·10	21½	2¾ „ 9¼	10 „ 40	2

It will be seen from this table that the piles Nos. 1 to 12 inclusive vary only about 3 feet to 4 feet in depth. These piles consist of one row of land piles and two rows of piles in the bed, whilst piles Nos. 13 to 17 inclusive, the row of piles on the other side of the river, are considerably shorter in consequence of its being found almost impracticable to screw them to a greater depth through the very fine silt met with and below-mentioned.

The strata through which the land piles Nos. 1 to 4 inclusive were screwed consisted more or less of: i. 5 feet of wet silty clay; ii. 1 foot of peat; iii. 2 feet 6 inches clay and peat mixed; iv. 7 inches of peat; v. 14 feet of light blue clay; vi. 2 inches of sand; vii. 3 inches of clay and shingle; viii. 2 inches of light blue clay and flints; ix. 6 inches light clay mixed with chalk; x. 6 inches light clay mixed with flints; xi. 8 inches dark clay and chalk with small stones; xii. 3 inches sand, clay, and flints; xiii. 2 inches sand and clay; and xiv. dark blue stiff clay.

The piles, Nos. 5 to 12 inclusive, were screwed into strata Nos. iv. to xiv., and the whole of the stratum through which the piles Nos. 13 to 17 were screwed consisted of extremely fine light brown silt, mixed with a small proportion of black silt.

To compensate for the shallow depth of the last four piles, the concrete retaining wall to the approach was constructed directly under the transverse girder, thereby affording a bearing surface the whole width of the bridge.

In screwing through the top bed of soft silty clay the piles sunk about 6 inches to 7 inches per revolution in 5 to 8 minutes, whilst through clay mixed with flint stones up to 2 inches across, at a greater depth, only ¼ inch to 1 inch per revolution was sunk in 7 to 12 minutes. In the dark, stiff, blue clay, without stones, at the greatest depth the piles sank 6 inches to 7 inches per revolution in 20 to 35 minutes.

In one or two cases, however, the pile sank about 7½ inches per revolution in this stratum in 40 minutes.

In screwing through extremely fine silt the piles sank in the first half of the depth 3½ inches to 7 inches per revolution in an average of 16 minutes, whilst in the lower half towards the greatest depth screwed they sank on an average of about 5 inches per revolution in 42 minutes, with four men on each crab, working at double purchase. One pile broke during the operation.

The pitch of the screw of the pile was about 9 inches.

COST OF SCREWING PILES.

Staff—Eleven men and a foreman; wages about 13*l.* per week.

Total number of feet screwed into solid ground, including that excavated, 425 feet.

Average to each pile, ditto ditto, 25 feet.

Labour only—Total cost of screwing, including all labour of every description, 145*l.*

Average cost per pile, 8*l.* 10*s.*

Average cost per foot depth screwed and excavated, 6*s.* 10*d.*

The above costs include,—

Constructing guides:—Rolling castings into position; bolting on capstan and putting in bars, &c.; placing crabs in position; removing stumps of old piles, average per pile (2*s.* 6*d.*); actual screwing and excavation and supervision.

The bridge was tested by four traction engines, weighing in all about 54 tons, which steamed over two abreast as close up to each other as possible.

The greatest deflection observed during the test was barely $\frac{1}{16}$th of an inch, and the girder resumed its original position.

Careful levels were taken on the parapet girders on each side of the bridge over each row of piles directly after the opening, and again about fifteen months later, when it was found that there was no difference whatever.

A temporary wooden bridge was constructed, to accommodate the traffic whilst the new bridge was being erected, at a cost of 165*l.*

I may here mention that the cost of driving the piles for the temporary bridge was about 5½*d.* per foot cube for the whole of the baulk, the piles being about 30 feet long and driven about 15 feet into the soil.

The principal contractors were Messrs. Goddard & Massey of Nottingham, and the sub-contractors for paving concrete work and the temporary bridge were Messrs. Bardell Bros. of Lynn.

The cost of the work was 3200*l.*

Mr. H. Geo. Coales acted as Resident Engineer.

DISCUSSION.

Mr. E. Buckham (Hon. Sec.): I rise, Sir, simply for the purpose of opening the discussion. In the first place, I should like to thank Mr. MacBrair most sincerely for his paper, and also for the very able assistance he has given me in arranging this meeting. Mr. Mawbey has been particularly kind, because on two occasions he came forward and assisted us by preparing papers. I will just say a word or two about one or two points in Mr. Mawbey's paper. First as to water-closets, I should like to know whether, in the case of the drainage of King's Lynn, the construction of water-closets in connection with the house-drainage arrangements was compulsory; and whether the whole of the house drainage was carried out under any special powers, or whether it was merely dealt with under the ordinary powers provided for in the Public Health Act? With regard to the mode of construction I fully agree with the author of the paper, that disconnecting syphons fixed between the house and the sewer are more or less objectionable. I have had a good deal to do with house drainage in my time. I have superintended the drainage of 6000 houses, and have only used syphons in exceptional cases. The plan I have always adopted is to disconnect all drains from the house by trap gullies outside, and in the case of water-closets to carry a ventilating pipe of the same size as the waste pipe up above the roof of the house. Just a word as to flushing and ventilation. Our sewers were, in the first instance, ventilated by open gratings level with the street surface, but in consequence of the continual complaints of the nuisances arising from these openings we decided to try some little improvement. After a great deal of consideration I decided to erect ventilating shafts which were carried up the gables of houses or other suitable places, so that the outlet of the pipe was in a position which did not endanger the health of the occupants of that or the adjoining property. I have also lately designed, or rather adapted, one of our ordinary lamp columns for sewerage ventilating purposes. I should like to have been able to have presented you with a drawing. It is a very simple thing—the hollow in the column acts as an upright shaft, and then the terminal air-cap is perforated with a series of openings about an inch square, the area of which is about twice the area of the inside of the column. They are fixed in safe positions in the high parts of the town, on the suburban roads where there are villa residences with large gardens in front. Of course to fix these ventilators in narrow streets in central parts of the town, would be objectionable, but in the places I have described there is no danger whatever, and I have fixed them with considerable success. We want as far as we can to be very careful in adopting any kind of patent column lamp ventilators. The column lately patented by Messrs. Holman and Keeling is an iron column something after the appearance of a lamp column with an atmospheric gas-burner at the top. This is supposed by the heat to create a current and induce ventilation, and at the same time to burn or annihilate all objectionable gases. I have no doubt it would work very well, but my objection to it is the cost. I estimate that at the very lowest in my town (Ipswich) we should require 500, and the first cost of 500 columns of that kind, coupled with the annual cost, would be something considerable; because, you must remember, they will always be going, day and night, from year's end to year's end. One wants to be very careful before adopting a thing of that kind to fully count the cost. In my opinion there is no need for it. I believe that the simple system of vertical shafts with hollow lamp columns in proper positions is all the ventilation that a system of sewers requires in towns. A word as to flushing. Flushing and ventilation are almost inseparable, because by keeping the temperature low in the sewers, as you do by flushing, you reduce very considerably the generation of objectionable gases. I always look upon flushing more as a means of purification, and as an adjunct to ventilation, than as a means of removing obstructions in the sewer. Of course to some extent flushing does remove obstruction in the sewer, where you get a good head of water and good gradients, but I look upon it as more valuable as a means of purification than as a means of removing obstructions. Some time ago I made extensive inquiries as to the means of ventilating sewers adopted in different towns throughout the country. I applied to thirty or forty towns, and I found that open gratings level with the street surface and vertical shafts, and also chimney shafts were the means most adopted, and in my judgment, up to the present time that plan has not been improved upon by any patent or other process which has been brought to the knowledge of sanitary engineers.

Mr. A. M. **Fowler**: Just two points, to follow Mr. Buckham with regard to the ventilation of sewers. Of course this is a very serious question nowadays—it is a question to which of necessity we must give very great attention. For myself, I think there is something really wanted in the perfection of our work in the first instance. I don't contend that sewers require no ventilation, but I say if they are properly laid they require very little ventilation. If the joints of the sewers are properly made and the sewers are truly laid, the sewage does not get rotten, and there is not a large amount of foul gas thrown off. One point in the proper laying of sewers is to see that you do not get the cement squeezed through the joints and so obstruct the flow of the sewage. With regard to the rainfall, and the quantity of water which entered the sewers, Mr. Mawbey mentioned a continuous rainfall of twenty-four hours. I contend that this is not of much consequence; it is the heavy storms that you have to provide for. It may rain for a week, or a month, if you like, if it comes down in a continuous drizzle, and it won't affect the sewers, but if you get a very heavy thunderstorm, such as the people in large towns are two well acquainted with, it is then that the capabilities of the storm outlets are put to the test. In Leeds I have had to alter the sewers to adapt them, not to the rain which would fall in twenty-four hours, but to a single thunderstorm. Our information with regard to heavy showers in different parts of England is very meagre indeed, and it would be a very good thing if members would put down a rain gauge recording in their different districts the amount of rain falling in a given time so that they might have something to guide them when they were regulating the capacity of their sewers to the heavy rainfall.

Mr. W. H. **Wheeler**, after thanking Mr. MacBrair and Mr. Mawbey for their papers, said: As my name has been mentioned in connection with the King's Lynn works, perhaps I may be allowed to say that I consider pumping would be more satisfactory than gravitation in a town situated like Lynn. The great obstacle, of course, is the expense, and this in a town like Lynn, which depends almost entirely upon agriculture, is a very serious one. The sewage is discharged into the river, where the immense volume of tidal water prevents the creation of any nuisance, and under the circumstances I did not think we should have been justified in going to any expense in works for purifying the sewage. The sewers were not designed on any complete system. A rivulet, which ran through some pleasure grounds, became so foul in consequence of the sewage which was discharged into it, that the inhabitants called upon the Corporation to abate the nuisance, and to abate it, I laid out the main sewer Mr. Mawbey has referred to. I had to bring in a number of small sewers, and at the top of each was placed an automatic flushing tank. I used Field's. Mr. Mawbey has used Adams's. I afterwards used some of Adams's in the adjoining village of Gaywood. We had some trouble with them, owing to the unusual shortness of the leg, but Messrs. Adams behaved exceedingly well—they altered the syphons, without charging extra, until at last we got them to work very satisfactorily. I should be very much obliged if Mr. Mawbey would kindly tell me which of the two he has found the best. With regard to the 2-inch rainfall, I think it is an excessive quantity for a district on the East Coast of England. I don't think it could ever be necessary to provide for such a large rainfall as that. The streets are generally so flat that the water does not rush down them at the same rate as in the hilly towns, and the district is not visited with such heavy thunderstorms as are experienced in other neighbourhoods. Of course there are storm overflows which would carry off any great and sudden downpour. With regard to the waterworks at Lynn, I think the people there must be very hardened; according to all sanitary laws, they ought all to have died long since. A worse water supply doesn't exist in England. They have no proper filtering tanks, but merely subsidence tanks, which are of little use. The water comes down past a churchyard and along an open channel where cattle go to drink. You cannot say that the water is filtered; it comes through a small quantity of sand very rapidly and is pumped up to supply the people of the town, who seem to live and thrive upon it. The amount of water pumped is absurd—70 gallons per head per day. There is a very peculiar system in vogue throughout the town. In times when water was scarce the inhabitants supplied themselves with large tanks for the purpose of storage. The people of Lynn are so devoted to these tanks that they will not have them done away with, but insist upon having them filled with water. They also like to have the water running about underground, the general idea being that the more water runs to waste the better. Probably they think the quantity makes up for lack of quality.

Mr. J. W. COCKRILL: The only remark I wish to make is that I have tried one of Adams's syphons, and have found it useless. I have had twelve annular syphons made by Doulton at work for four years without a hitch.

Mr. EAYRS: I have tried Adams's, and I consider them better than either Doulton's or Field's.

Mr. **Buckham**: In using some of Adams's earlier make of syphons I found they were not always reliable; but it is only fair to the manufacturers to say that since that time they have been much improved, but I am bound to admit that I do not admire the way in which the improvements have been effected. I know of no syphon that can be put down as absolutely perfect in practical working.

Mr. R. **Vawser**: The remarks just made by gentlemen who have volunteered their opinions upon the different syphons, show that at any rate there is a difference of opinion amongst us with regard to matters of detail, and it is rather singular that the question of the working of syphons when used for flushing sewers, is one of the matters on which I desired to have the opinion of members of the Association: perhaps those who have spoken are a fair reflection of those who have not, and therefore I am afraid I must go for information to some other source, because I cannot altogether take the opinion of the members of the Association on so important a subject if six think one way and half-a-dozen think the other. Mr. Fowler referred to a point mentioned in Mr. Mawbey's paper on the subject of the depth of rainfall to be provided for by the sewers. My experience leads me to conclude that a rainfall of one or two inches, evenly distributed over twenty-four hours, is very small indeed, and that unless you provide for extraordinary rainfalls in constructing entirely new sewers, you would probably get yourselves into a difficulty. We often have in the district I come from a rainfall of one inch an hour, and sometimes a great deal more. And what you have to provide for is the maximum quantity of rainfall:—not for extraordinary rains such as have never occurred before, but for such rains as are of frequent occurrence in your district. I am quite aware that in the eastern counties district, the rainfall is less heavy than in the north, but Mr. Mawbey has told us that one night there was a rainfall of 3¾ inches. That might lead you to suppose it was evenly distributed during twelve hours through the night, but it might have fallen in an hour and a half, and the probability is it did, because if you are visited by heavy rains in that district they are very heavy indeed, and therefore I consider that to provide for two inches evenly distributed per day is altogether a delusion and a snare in designing outfall sewerage works. I have referred to this matter once or twice previously in discussions before our Association, and the more I think the more strongly I am convinced that engineers as a rule provide for too little rather than too much.

I had hoped coming here to-day, we should have heard something upon a question of very great interest to the engineering world at the present time, a question which I consider of vital importance with regard to the treatment of sewage upon land, i.e. the treatment of the maximum quantity of sewage on the minimum quantity of land. In my district, the district of Lancashire, it is no uncommon thing for the Local Board to be asked 1000*l.* per acre for land they require for sewage purification purposes, and therefore it is a matter of extreme importance that land should be minimised. It does not matter whether you erect two or three extra tanks; if you save the cost of five or six acres of land by the process, you are a clear gainer by the transaction. We have often heard that by treating raw sewage by what is called intermittent filtration, you can dispose of a certain quantity of sewage per annum. We are then again told that by applying lime or some other chemical to the sewage, so much more per acre will be absorbed, that is to say, that you can deal with seven or ten or perhaps twenty times as much sewage when lime is used as you can without lime. I should be glad if Mr. MacBrair would kindly tell us what the result of his actual experiment has been.

The **President**: I should like to have said a few words on both papers, but time is getting short. We have been honoured to-day with the presence of a gentleman who represents the Corporation of this ancient city, Mr. Alderman Maltby, who takes great interest in the works we have visited, and also in the Association which we represent. I regret that the time at our disposal is utterly inadequate to do justice to what we have seen or what we have heard. Had it been otherwise, Alderman Maltby would have heard some expressions of opinion on the many things we have seen. He must, however, take the will for the deed, and if we again visit Lincoln I hope we shall have more time at our disposal.

Mr. **Mawbey**: In reply to Mr. Buckham, the house drainage was carried out in accordance with regulations drawn up by me, and adopted by the Corporation in pursuance of section 21 of the Public Health Act, 1875. Neither under those regulations, or the notices served requiring new drainage to be executed, could water-closets be enforced; but in cases where existing privies were too near to houses, a notice was served under section 94 requiring the owner to abate the nuisance, and for that purpose to construct water-closets. Respecting the several remarks on the provision for rainfall, I may say that at Lynn I provided as far as practicable for sudden heavy rainfalls, by a number of storm overflows at short distances apart on the main intercepting sewers leading direct to the river. I take it that few engineers would think of making their sewers proper large enough to carry off the rainfall of great storms.

As to whose flushing syphons are the best, I have at Lynn and other places had the opportunity of daily observing the behaviour of a number of both Field's and Adams's automatic syphons for sewer flushing (and also in my capacity as waterworks engineer at Lynn numerous automatic syphons flushing tanks for trough closets and water-closets), and have found both Adams's and Field's to act admirably. Some of them have never failed; but other of the syphons of both these inventors have occasionally failed to act. The proper working of syphons, especially if worked with sewage, depends on such careful fixing and delicate adjustment, that before an engineer condemns any particular syphon, he should himself enter the tank and ascertain at least if it is properly fixed. Messrs. Adams and Co. have recently brought out an improved flushing syphon provided with a vent pipe, carried up from the trap, which they guarantee, and which has no air hole in the syphon to become choked. I have not, however, at present tried one of these.

Mr. MacBrair: In reply to Mr. Vawser, who is somewhat disappointed that he has not received "light and leading" on the question of the quantity of land required—either for broad irrigation or intermittent filtration purposes for a given population—I may state that in my opinion it is impossible to lay down any infallible rule. The situation, nature of the soil, degree of perfection of under drainage, &c., play such important parts, that it is impossible to dogmatise on the matter. I can simply add my small quota of experience, which is, that sewage percolates land much quicker when it has been previously precipitated. When I tried the lime treatment, I kept some terraces solely for the treated effluent, and found that no scum or film was formed in the trenches, whereas on the rest of the farm the sediment of the untreated sewage had covered the trenches with a green, almost impermeable slime, giving off much effluvia. Our farm of 60 acres only gives about 1 acre to every 700 of population—too little in my opinion. To farm to the best advantage several times this quantity of land is needed. We can certainly take all the sewage upon our farm, but we have sometimes to sewage our crops with the certain knowledge that it will do them harm. I should certainly say that precipitation would lessen *materially* the quantity of land required for a given population. Our honorary secretary, Mr. Buckham, asks how we carried out our works of house corrections. Before we commenced these, we issued a set of regulations under the authority of sect. 21 of the Public Health Act, 1875. These were based on the Local Government Model Bye-laws. After this was done we took the city in sections, or blocks of streets and houses containing from 100 to 200 houses each (as the streets came convenient), and issued notices upon every owner. At the same time various persons in different parts of the city, who knew the value of proper sewerage, connected their houses: every person of course depositing a plan of proposed drainage, the whole of the work being done under proper supervision. We connected about 9000 houses—practically all the houses that could be drained. The work was done with so little friction that we only had to issue *one* summons, and that was against an owner who would put up a 2-inch ventilating pipe instead of a 4-inch one!

A vote of thanks was passed to the Mayor for the use of the Guild Hall.

Immediately after the reading of the papers the members of the Association and visitors were driven to the Sewage Pumping Station, where they inspected the engine and boilers, the special features of which were pointed out by Mr. MacBrair. They then visited the Sewage Farm and Filter-Press Works, where the process explained in Mr. MacBrair's paper was practically demonstrated. After inspecting the settling tanks the members were conducted to the mixing chamber, from which the lime is forced into the effluent sewage on the one hand and into the sewage sludge on the other. They next visited the press-house, where two filter presses were seen in operation. Subsequently a visit was paid to the Waterworks, where the members were received by the engineer, Mr. Teague, who explained the merits of recent improvements in the new Cornish engine. The members then returned to the Guild Hall, where the discussion was opened.

DISTRICT MEETING AT LEAMINGTON.

May 26th, 1888.

Held in the Council Chamber, Town Hall, Leamington.

JOSEPH GORDON, *President, in the Chair.*

THE Mayor of Leamington (John Fell, Esq.) opened the proceedings by very cordially welcoming the Association to the town. The President having acknowledged the compliment, mentioned that this was the first occasion the Association had received an official invitation from the chief magistrate of any borough, and trusted that other authorities would follow the excellent example set by the Mayor of Leamington.

The following paper was then read and discussed :—

LEAMINGTON SPA WATER SUPPLY.

BY W. DE NORMANVILLE, ASSOC. M. INST. C.E., BOROUGH SURVEYOR.

IN treating of the water supply of a town, it is advisable at the outset to explain what are the needs to be provided for. It may therefore be premised, that the area of Leamington Spa is 1571 acres, and its population 24,300; but to this must be added the populations of the two adjoining parishes of Milverton and Lillington, which depend upon Leamington for their water supply, so that the total number of persons dependent on the Corporation Waterworks is about 28,000. Every house throughout the district is provided with one or more w.c.'s, and very many have baths, so that the demands upon the water supply are greater than in other towns of similar population.

OLD WORKS.

Until the year 1878, Leamington derived its water supply from the small river which flows through it, and from which it takes its name. Like, however, most other streams in this country, the Leam had degenerated, and its once pellucid waters were gravely suspected of bearing within them matters cf a nature at variance with the objects of a health resort. After much consideration, and yet more discussion, it was therefore decided by the authorities to seek an entirely new source of supply. Sir Andrew Ramsay, late Director-General of Geological Surveys, having been consulted as to the likelihood of obtaining a supply from subterranean sources, counselled the sinking of a well.

SINKING OF WELLS.

This advice was followed, and a pilot shaft 8 feet diameter, and subsequently a well 20 feet diameter, were sunk in the north-eastern corner of the town. The former was sunk to a depth of 105 feet, and the latter to a depth of 110 feet. From the bottom of each an 18-inch bore was put down, that in the large well attaining a total depth of about 220 feet from the surface, and that in the small well a depth of 240 feet. Only a small quantity of water was obtained from the bore in the large well, but from that in the small well large quantities were yielded as soon as it had been driven a few feet. It may here be convenient to say a few words on the geology of the district. Leamington stands on the new red sandstone formation, and the wells after passing through alternate strata of various coloured sandstone and marls, terminate in the keuper or waterstones division of this formation. This water-bearing bed has its outcrop at Warwick, Guy's Cliff, Leek Wootton, Milverton, and Cubbington, and beneath Leamington is about 45 feet thick. The two wells penetrate it to a depth of 21 feet and 26 feet respectively, leaving 19 feet of water-bearing stone between them and the impervious stratum forming the bottom of the basin. The water derived from this source is of excellent quality, though somewhat hard for washing purposes—its hardness being 28 degrees. Dr. Tidy, the eminent analyst, speaks of it as a water "in every respect of excellent quality, and for wholesomeness leaving nothing to be desired." On the completion of the large well it was decided to unite it to the smaller one by a heading 6 feet high by 4 feet wide. In driving this heading a fissure in the rock, about 2 feet 6 inches long, and having a maximum width of some 10 inches, was met with in the bottom, from which such volumes of water flowed as defied the efforts of the contractor to pen them back during the completion of the works, the fixing of the lower portions of the pumps, &c. Coincidently with this influx of water from the fissure the previously abundant yield from the bore in the pilot well fell off, showing that the fissure and the bore, which are but 35 feet apart, were yielding water from the same source. Headings driven in the summer of 1886 have proved this to be the case, and indicate the existence of a horizontal cavity in the rock, extending northwards, eastwards, and westwards of the pilot well, and having a depth which varies from 9 to 15 inches. This cavity is the source from which the whole of the Leamington supply is derived, and when first tapped probably was capable of yielding some 2,000,000 gallons per day. Since then, however, the line of saturation has materially subsided, and with it of course the yield, which nevertheless remains abundant for the present or an increased population, even with a constant service, provided only that waste be kept within reasonable limits. In the year 1881 the line of saturation, even in the middle of summer, was 44 feet above the bottom of the well. The highest point it has reached during the past two years is 30 feet, but there is reason to believe that, with the return of ordinary rainfalls, and with a gradually diminishing waste, a level somewhat approaching that of 1881 may be reached again.

THE MACHINERY.

Following a description of the wells naturally comes that of the machinery, by which the water is raised from them to the reservoirs. The pumps are arranged in two pairs—one the duplicate of the other—and are fixed to cast-iron girders carried by the brick lining of the well, at such a level as that the suction valves are about 18 feet above the bottom of the well. They are of the bucket and plunger type, the buckets being 18 inches diameter and the plungers 12¾ inches, with a stroke of 5 feet. The buckets and valves are entirely of gun-metal, and the barrels are lined with the same material. Four-inch diameter wrought-iron rods connect the pumps with the crank shaft at the top of the well. The cranks are set at right angles to each other, and as the pumps are double-acting, it follows that the stream of water delivered by them is uniform, and the work put upon the engine also uniform. The pump crank-shafts, one each side of the well, are carried on heavy wrought-iron plate web girders 5 feet deep, which span the well; and are supported on concrete piers, 10 feet by 5 feet, in horizontal section, which are founded on rock 22 feet below the engine-house floor. The crank shaft of each pair of pumps carries near its centre an 8-feet diameter spur-wheel, into which gears a 2-feet pinion, thus increasing the relative power, and diminishing the relative speed of engine to pumps by four. The engine shaft crosses the well at its centre, parallel to the pump shafts, with which, as already stated, it engages by gearing. The engines themselves, which, in common with the rest of the machinery, are in duplicate, are horizontal, single-cylinder condensing engines. The cylinders are 21 inches diameter, by 3 feet 6 inches stroke, fitted with ordinary slide valves worked by eccentrics. This form of valve in engines of this size is ill adapted to its work, on account of the enormous friction arising from the large rubbing surfaces exposed to the pressure of the steam. The engines used to be worked with 60 lbs. of steam, and a quick cut-off, but latterly a great improvement in their working has been effected by using only 40 lbs. of steam, and lengthening the duration of its admission to the cylinder. The excessive friction of the slide valve is thus reduced, and many jars and sudden strains are removed from the machinery. The speed of the engines is 40 or 38 revolutions per minute. This gives 10 or 9½ revolutions to the pump shafts, which speed produces a flow in the rising main—which is 16 inches diameter—of about 120 feet per minute. At this speed the engines and pumps work smoothly, though there is a slight back-lash in the gearing, in consequence of the counterpoises on the pump spur-wheels being rather less than the weight of cranks and connecting rods which they are supposed to balance. This deficiency of counterpoise is due to the fact that the connecting rods of the pumps were originally hollow, whereas they are now solid. The condenser is a surface condenser. Its air-pump was originally a direct-acting pump, by Wilson, of London. A more unsuitable form of pump for a condenser could hardly be designed. Its steam cylinder has lately been done away with, and its place taken by a connecting rod and disc crank attached to the old pump and driven by belting from the main shaft of the engine. This works very satisfactorily, and has resulted in a saving of upwards of two tons of coal per week. The height to which the water is lifted to the reservoir varies slightly, according to the depth of water in the well, but averages about 165 to 170 feet. The water pumped varies from 3½ to 4½ million gallons per week, though in the future, owing to the very considerable reduction in waste lately effected, it is doubtful if the latter quantity will again be needed. The consumption of coal varies from nine to twelve tons per week. The boilers are three in number, of the Lancashire type, 7 feet diameter and 30 feet long.

The Cost of the Works.

The total cost of these works, including land, boiler-house and engine-house, the rising main, 570 yards long, a valve pit, and some slight alterations at the reservoirs, was a little over 31,000*l.* Sundry alterations and improvements effected by Sir F. Bramwell about five years ago, brought the total cost of the works in their present form to very nearly 35,000*l.* Of this sum, however, about 1500*l.* was expended in litigation. Previous to the construction of the above works, about 16,000*l.* had been expended on mains and reservoirs, the old pumping machinery, filter beds, &c., being the property of a contractor who supplied river water to the town till the year 1878. The reservoirs just referred to were designed in 1856 by Mr. Wicksteed of London. They each hold 500,000 gallons. They are circular in plan, are underground, and are vaulted over with brick. They are each 72 feet diameter by 21 feet deep to top water. Their bottoms and sides are constructed of brick, backed with concrete and puddle.

Distributing Mains.

Till about the year 1880 the trunk or principal mains remained precisely as Mr. Wicksteed had left them, when he constructed the reservoirs in 1856, whereas the subsidiary mains had been stretched out in all directions, as the town grew, with the natural result that in the high parts of the borough, but especially in the adjoining parishes, great inconvenience was experienced from want of pressure. To remedy this defect a 12-inch pipe was laid from the rising main in the waterworks yard into the town, and there connected to the nearest trunk main. This effected a considerable improvement, but only during pumping hours, for, as the rising main delivers its water at the top of the reservoirs, there was of course no supply for this new 12-inch pipe, when the pumps ceased working. This want of pressure in the mains was also a serious defect in cases of fire. To remedy these defects the writer proposed two years ago the addition of sundry large mains in the town, and the erection at the reservoirs of a 40-feet standpipe, which works were carried out. As the standpipe is a little out of the common a short description of it may be interesting. It is not open at the top, as is usual, but closed quite air-tight. One leg is of 18 inches diameter, the other of but 9 inches. The rising main runs through both legs at the base, and when the standpipe is not in use, the water thus finds its way to the reservoir. The end of the rising main is bent down into the reservoir till within 9 inches of the bottom, so as to form—under conditions presently to be described—a syphon. Between the two legs of the standpipe a valve is fixed in the rising main. If this valve be closed whilst the pumps are at work, the water immediately ascends the large leg of the standpipe and falls down the small one, thus flowing by the horizontal pipe into the reservoir. A 2-inch brass cock in the small leg allows the pent-up air to escape. If now this air cock be shut and the valve between the legs of the standpipe be opened, the water in the large leg will descend and flow through the valve into the reservoir. As it descends, the air in the small leg and any air that there may be in the rising main expands into its place and becomes so rarefied that the atmospheric pressure on the surface of the water in the reservoir forces it several feet up both legs of the standpipe, and thus, when the pumps cease working, the rising main remains charged as a syphon and so works all night. The partial vacuum formed, as just described, is so good, that if there be only two feet of water in the reservoir, it nevertheless works over the syphon freely. If the pumps be worked when the apparatus is in its syphon condition just described, and the water happens to be rather low in the reservoirs, the pumps are relieved of pressure just in proportion to the number of feet that the water-level is below the rising main. When the apparatus is used as a mere standpipe it of course works in the usual way, excepting only that the air, instead of escaping at top, is forced out by the small cock a few feet above the ground.

INCREASING THE SUPPLY.

In the droughty summer of 1886, excessive garden and lawn watering with other misuse and waste increased the consumption of water in the borough to 29 gallons per head per day, the daily demand on the works being but little under 1,000,000 gallons per day, or rather more than the springs were yielding. It was therefore determined that some means should be taken to increase the supply. The writer, after considerable study of the subject, proposed the deepening of the well and a portion of the heading (as far as the fissure in the bottom of it, from which very nearly all the supply flowed), and the lowering of the suction portion of one pair of pumps, to the extent of 10 feet. It may be explained that the fissure's direction is downwards, at an angle of about sixty degrees with the horizon. The following is quoted from the writer's report made at the period referred to:—"The reason of the supply having of late fallen off is simply that the line of saturation in the water-bearing rock, from which it is obtained, is at present some 10 feet lower than it used to be, owing to the light rainfall of the past eighteen months. In other words, with the subterranean waters at their present level, the well does not dip deeply enough into them to obtain a rapid supply. These waters at present stand but 28 feet above the bottom of the well. Last winter they were 33 feet above, and in the previous April and May they were 40 feet above. At that period the difference of level (or head), between the fissure from which the water flows, and the line of saturation, or upper surface of the water in the rock, was sufficient to produce an inflow of 1,700,000 gallons per day. If the well and heading, as far as, and following down the fissure, be lowered 10 feet, the old head, or difference of level, will be restored, and bring back something like the old yield. The cost of lowering a portion of the well and heading, together with the suction portion of one pair of pumps, will not exceed 400*l.*" This extract from the writer's report and the drawing on the table no doubt sufficiently explain the scheme, in which of course there was no novelty, as it was merely what every waterworks engineer has frequently to have recourse to. A counter scheme, however, for driving headings was decided on. Accordingly two were driven, one at right angles to the other, one to a distance of over 100 feet, and the other to twice that distance. These headings were to be 6 feet by 4 feet, but owing to the way the miners executed them they are considerably larger, and therefore provide considerable underground storage. Very soon after commencing the first heading a large aperture was made into the horizontal cavity, of which mention has been made as the source supply. From this opening four or five hundred thousand gallons per day at once gushed forth, but with the result of diminishing the flow from the old fissure by almost the same amount. In several other places, as the headings were proceeded with, the same cavity was broken into, and from all these openings the water now flows with a net gain of some 60,000 gallons per day. The cost of driving the headings was 850*l.*

PLANS FOR SAVING WATER.

The light rains of the winter of 1886–7, and the signs of the following summer being once more droughty, again brought the subject of water supply on the tapis, and the writer then recommended the two following methods of husbanding present resources, viz.: Firstly, the use of river water for laying the dust in the streets, and secondly the adoption of Deacon's waste-water meters for the detection of waste. Both these methods have been adopted, and are now in daily use, with the satisfactory result that, despite the fact of last year's rainfall in these regions having been but 17 inches, instead of the average of 26 inches, and of this year's fall, up to the present time, being at the rate of but 15 inches per annum, instead of 26 inches; the line of saturation is now 30 feet above the bottom of the well, instead of 24 feet as at this time last year, and the quantity of water used last month was but 14,094,000 gallons, instead of 19,441,000 gallons as used in the corresponding month last year. Of this diminution of nearly 5¼ million gallons, 1¼ million is due to not using the water on the streets, and the remaining 4¼ millions to the reduction of waste. The scheme for watering the streets with river water is the following:—At the Pump Room baths, which are close by the river, and where sufficient boiler power for the purpose already existed, and where also the exhaust steam could be utilised for heating purposes, a direct-acting and double-acting steam pump has been fixed. It is one of Donkin's patent, manufactured by Joseph Evans, of Wolverhampton. The steam cylinder is 15 inches diameter, the pump 10 inches diameter, and the stroke is 24 inches. At 50 strokes per minute, it throws 20,000 gallons per hour, and at 60 strokes 24,000 gallons. The suction and delivery pipes are 8 inches diameter. On reaching the street the delivery is branched into two six-inch pipes, one running northwards for a distance of 1080 yards, and the other southwards for a distance of 350 yards. From the former, a four-inch pipe carries the water to a total distance from the pump of a mile. In a southerly direction, the most distant street watering post is 1180 yards off. From both these pipes there are various branches supplying in all 15 posts. The posts have 3-inch clear-way valves, and are furnished with swan necks of either 2 inches, 2½ inches, or 3 inches diameter, according to the level of the ground, and consequent intensity of pressure. The pump is provided with an air vessel somewhat larger than the normal size due to its diameter. Attached to this air vessel is a small cylinder, 3 inches diameter and about 3 inches long, and brass lined. Its position is horizontal. In this cylinder is a piston packed with a cupped leather, which is forced in against the water by a steel spring of such strength, that when the pressure in the air vessel is about 60 lbs. per inch, it yields, and the rod connected to the piston is forced outwards. This rod is about 2 feet 6 inches long, and is attached to an equilibrium valve in the steam pipe, which, as the pressure in the air vessel rises above 60 lbs., it gradually closes, until, when a pressure of 70 or 75 lbs. is reached, the steam is cut off and the engine stops. As soon as a valve in the mains is opened, the pressure in the air vessel diminishes, the governor piston is forced inwards by the spring, and the steam valve is again opened. As by the opening of other hydrants, the pressure further falls, the steam valve is fully opened, and thus the engine works automatically. There is no standpipe nor water tower, the water being pumped into closed mains; but to supply the place of these, without incurring their expense, an air vessel has been erected in the high part of the town, consisting of two lengths of 24-inch pipes. This takes off all sudden strains caused by the closing of two or three hydrants at a time, and further acts to some extent as an accumulator. Twelve vans and five carts are supplied by this scheme. As a rule two or three hydrants are open at one time, occasionally four or even five and sometimes only one or none. When the nature of the weather needs only half-a-dozen or so of vans to be out, the automatic cut-off or governor is constantly in requisition, and is very useful. The total length of mains, including 6-inch, 4-inch, and 3-inch pipes, embraced in this scheme, is 5200 yards. The total cost has been 930*l.*

Deacon's Waste Water Meters.

Though the principle and action of Deacon's Waste Water Meters may be familiar to most present, a few words on the result of their use in this borough may be of interest. One of these meters has been in use in the north-eastern part of the town for some seven or eight years, but it was only at the beginning of the present year that the purchase of five more enabled the system to be applied to the whole of the borough. For this purpose the town has been divided into ten districts, each containing from 2000 to 3000 inhabitants. Each meter is so placed as to be applicable to two districts. For the perfect and most simple working of the Deacon system each house ought to be provided with an outside stopcock. In Leamington not more than one-sixth of the houses are so provided. Excellent results can however be obtained without these outside stopcocks. A diagram used on a meter in any district for twenty-four hours, shows the total amount of water used in the district and also the proportion of waste. If the district be bad, a second diagram used at night, whilst a turncock shuts off at regular intervals—say of twenty minutes—the various streets comprised in the district, will indicate in which streets and to what extent in each of such streets waste is going on. Assume that the district comprises twelve "shuts"—some perhaps embracing two streets—the chief waste is probably confined to three or four, perhaps only two. These are the streets into which the day inspector is sent, and the inhabitants of the other streets remain unmolested. But, further than this, the inspector can be informed of the quantity of water being wasted in each street which he has to inspect. Assume that in a certain street the amount is 250 gallons per hour, and that the street contains forty houses. When he has found leakages to account for the given quantity, which he may do in the first dozen or even half-dozen houses, his work in that street is complete, and he need not trouble the rest of the inhabitants. The work of inspection is thus reduced to a minimum. Perhaps, however, the most useful work of the Deacon's meter is its detection of underground or hidden waste, burst services, faulty hydrants, blown joints of mains, and occasionally fractured mains. These have been the chief sources of waste in Leamington, especially the ball hydrants, which, if the ball be worn, may be quite tight one day, yet, if a shut takes place and the ball falls, leak badly the next day, the water getting away into a porous subsoil or into a neighbouring drain or sewer. On the table lie the first and last diagrams taken in some of the districts of this borough. It will be seen that in district No. 9 the waste has been reduced from 42,000 gallons to 20,000 gallons per day, in district No. 10 from 34,000 gallons to 12,000 gallons per day, in district No. 1 from 14,600 gallons to 5160 gallons per day, in district No. 3 from 31,000 gallons to 1200 gallons per day, whilst in the diagram taken from district No. 4 is instanced the way in which a fractured main is at once indicated. The particulars of this diagram were given to the writer between three and four o'clock, and by nine o'clock the burst had been found and the waste of water—64,000 gallons per day—stopped. The whole of this large volume of water was getting away invisibly underground by an old drain into a neighbouring sewer, without the least indication on the surface. Since the meters were fixed at the beginning of the year, the waste has been reduced by about 130,000 gallons per day, with the satisfactory results to which reference has been made above. Taking the value of water at only 3*d.* per thousand gallons, this represents nearly 590*l.* per annum. These meters thus more than pay for themselves in less than a year, for the cost of providing and fixing them in Leamington has been but 365*l.* This includes the fixing of thirty-one additional valves in the mains, which are not properly chargeable to the meters account, as they were much needed for the general purposes of water supply.

DISCUSSION.

Mr. PRITCHARD: First of all I desire to thank the Mayor for his great kindness and hospitality in inviting the Association to hold a meeting in Leamington. I have had the pleasure of his acquaintance for many years, and I know his value. It is now perhaps fifteen or sixteen years since we had a most successful meeting here, shortly after the completion of the new sewage works. At that time every member of the Association was highly delighted with the visit, not only with the instruction we received, but also with the unparalleled beauty of Leamington as a watering-place. It is often called, and I think rightly so, the Queen of watering-places. It has been remarked that we have a very large attendance to-day, and I do not wonder at it. No doubt every gentleman who was here fifteen or sixteen years ago has made an effort to come here again to-day; and not only to come himself, but to advise his friends also to come. That is saying something in favour of Leamington as a sanitary town and I hope our visit may have the effect in the future of doing good to this beautiful town and its able Corporation, headed by our friend the Mayor. I desire also to thank the borough surveyor for the opportunity he has afforded us to-day of inspecting the works in the town, and for his very instructive paper although bristling with technicalities. As we have been informed in the paper, Leamington was once supplied with water from the river Leam, a river more or less polluted. That state of things could not long exist, and I think, very properly indeed, the Local Board of Health of Leamington determined to get water from another and purer source. I see before me now one of the staunchest supporters of that water scheme, my friend Mr. Bright, who, at that time, was chairman of the local board. In coming to this determination I think the board acted most wisely, because at this time the least sickness in any of the health resorts was published at once in competing towns, and people were advised not to go there. The Leamington Local Board, therefore, felt it to be their duty to put Leamington above suspicion in the matter of its water supply, and I believe they have done so. I was not, however, always of that opinion. In 1875, I think, the first well was sunk to the depth of 90 or 95 feet. At that time I was invited to determine what quantity of water was flowing from this source, and being pumped from the well. I think it was said there was something like a million gallons of water being supplied, but I found there was only 250,000 or 260,000 gallons per day. The Local Board proceeded further with the works and sunk another well, which they connected with the other well by means of an adit, and also put a bore down to a considerable depth. I was then invited by the promoters of the water scheme—before I had been asked by the opponents—to test the quantity of water being pumped, and I found to my astonishment that there were 1,250,000 or 1,500,000 gallons of water being obtained with very little addition to the works, except so far as regards the sinking of the second well and the construction of the adit. During the visit of the Sanitary Institute of Great Britain to Leamington, Mr. Baldwin Latham and myself were invited by Mr. Bright to make an investigation—a sort of friendly examination or inspection of the then partially completed supply. We did so, and we certainly came to the conclusion that the well was supplying water, and that the bore was also supplying water, but only to a certain portion of its depth—that a portion of this boring in fact was, we thought at the time (possibly we may have formed a wrong conclusion) silted up; that was the portion below the outcrop of the water from the veins referred to by the author of the paper. The opinion then formed was, that so long as this geological strata, cleared of clay and marl, so long as this open stratification remained, and so long as there was plenty of rainfall, so long would there be plenty of water for Leamington. Next came a point of some difficulty, but a most important one for Leamington—the quality of the water. The small surface wells in the neighbourhood were said to be affected by the pumping operations of the local board, and as these wells to a certain extent contained polluted water, we thought the natural result would be that this polluted water would find its way to the works of the local board. We predicted at that time, to the best of our belief, that there would be plenty of water so long as the ordinary rainfall continued, that the prevalence in Leamington of zymotic diseases would very soon determine the question of purity. Now, sir, what is the result? I did not hear that Mr. De Normanville in his paper said anything about the analysis, and I have just glanced over the annual report of the Medical Officer of Health, but I do not see that he refers to it either there. But I do know myself as a fact, that the results of an analysis by Dr. Tidy and other eminent men, that the water of Leamington is without doubt a very pure water indeed. Therefore the theory as to its possible pollution by water from the shallow surface wells disappears. The death-rate of Leamington will compare very favourably with any health resort in the kingdom. We now find the line of saturation is varying, and I rather gather from the author's remarks, that at one time the water in the well stood at the depth of 40 feet, but that now it is usually about 24 feet. I also find that, in 1886, by an extension of the works in the form of adits, a very considerable increase of water took place, to the extent of about 66,000 gallons per day. That was an important fact, because it showed Leamington is supplied from an exceedingly large area of collection. If it became necessary to increase the water supply of Leamington, I certainly should not approve of a short depth of sinking to obtain that increase of water. I think, by the extension of adits, there would be far greater probability of water being found than there would be by boring, unless the bore is taken to a great depth. But if a bore is taken to a great depth, there are two risks—one that water might not be found at a reasonable depth, and the other, that if it were found it might be brackish, and very inferior in quality to the present supply. I believe that by increasing the adits at Leamington an increased supply of water would be obtained. I am informed that within a very short distance of the well, there is a very abundant supply of water pumped daily for the use of an important brewery. This would rather point to the fact that water is to be found, if the means of inducing it to flow to the well are provided. The rainfall only having been 17 inches for the past twelve months, points also to the fact that water would be found in sufficient abundance for Leamington and the district. Reference has been made to economising the supply of water, and I think that it is an important point, which will have to occupy the consideration, more or less, of every water company and every town throughout the country. I believe at the present time water is wasted to a greater extent than it should be. I do not know whether I caught the right figures, but it struck me that 29 gallons per head per day, for a population like that of Leamington, was an enormous quantity. I listened very attentively to the means adopted for checking waste; whilst those who have any knowledge of Deacon's waste-water meter will admit it is a most ingenious mechanical contrivance, I do not think it is adaptable in every instance. It is expensive, and I would venture to point out that the same results may be obtained with less expenditure. A constant supply of water will doubtless give less room for waste than an intermittent supply. This may seem somewhat illogical, but my experience is, where people are not always sure of having water, when there is an intermittent supply, they have a habit of opening their taps and leaving them open until the water comes. We had an example of this in the county town of Warwick. With an intermittent supply the consumption was 44 gallons per head of the population. A constant supply was given to the town, Kennedy's meters were placed upon the supply main, and by controlling the water mains and services by sluice valves and stop taps the consumption was cut down from 44 gallons to 17 or 18 gallons per head. What was done first of all was to determine the quantity of water coming into the town, and particularly what quantity passed in the night time. I think between twelve o'clock at night and five o'clock in the morning some 160,000 gallons were registered as having passed. We found that this must have been running largely to waste. Then the surveyor proposed to shut off the various districts, of which he had nine, controlled by separate sluice-valves. He accordingly shut off one after another until he localised the district that was really wasting the water. In many instances the water was passing through pipes that were defective, and through taps that were defective, but was detected by means of the sounding rod. Leamington, however, I think, must not be classed with Warwick. Whilst 17 or 18 gallons per head might be sufficient for a town like Warwick, Leamington requires a larger quantity. It is of paramount importance in the future to water companies, local authorities, and even water consumers themselves, to utilise as far as they can the water supply, and to guard against the least waste. I do not think I can add anything to the opinions I have already expressed. I may be right or I may be wrong in some of them, but they are the results of my experience in various parts of the country.

Councillor H. Bright, J.P.: I do not know, Mr. Chairman and gentlemen, that I can add anything to the information you already possess respecting our Leamington water supply, except perhaps this, that if any of you are in great difficulties with your water supply, you might follow the example of the gentlemen who acted with me some twelve or fourteen years ago, and not be discouraged by opposition. First ascertain that you are in the right direction, and then stick to it through thick and thin till you have obtained what you require. I believe it was in 1870 we first took up this question. It arose from the fact that our river, from having been a very pellucid country stream, became polluted by the riparian owners above Leamington, first at Offchurch, and on for nine miles further as far as Southam. The result was that the water, which was at one time quite good enough for any one to drink, became so polluted that, though it might serve for domestic purposes, it was altogether unfit for drinking. Failing to get courage enough into the Local Board to fight the riparian owners who were fouling the stream, we took the other side of the question, and endeavoured to find some other source which was not polluted. At that time Alderman Wackrill, who is now present, and one or two others who have passed away from the scene of this world, went to Professor Ramsay, of the School of Mines, and it was on the information and advice which he gave that we formed the opinion we had water under our feet, and in sufficient quantity and of good quality for a town supply. We met with a great deal of opposition, and personally

I had to bear a good deal of obloquy, but I am happy to say I am alive to tell the story, and in a good state of health. We were told we were lunatics to suppose that there was sufficient water under our feet, and that if we did bore we should simply empty all the surface wells, and there would be an end of it. But having the advice of a man of such eminence as Professor Ramsay, who assured us that, from his knowledge of the strata (and he himself mapped this district for the Government at the time Sir Roderick Murchison held the chair), he was quite certain if we bored, though we might fail once, twice, or thrice, we should be sure to succeed in the end, we did bore, and with the unfortunate result that we got salt water. But we were not discouraged. A year passed by, and we again plucked up courage, and obtained a majority of one on our governing body, which gave us the power to go on again. This time we bored higher up the hill, instead of at the bottom of it, and the result was that we obtained the water before it had had time to mix with the saline marls at the lower level. We there got the water as you have seen it to-day, in a pure condition and abundant in quantity, and the results have been eminently satisfactory to all who were engaged in the undertaking. The supply, I am satisfied, is only limited by the quantity of area you bare, as the rock is fully saturated. At first, from the small well we only got 275,000 gallons, but the more we bared the rock the more water we got. The fact is the rock at about 100 feet is saturated, and from the geological maps and experiments made in various districts, it is quite evident this saturated rock continues in a northwesterly direction as far as Coventry. The whole of it is not exposed, as there is a large quantity covered with marl, but it all contains water. This is quite clear: there is a large portion of rock saturated with water, and the more we bare the surface of the rock, the more water you get from it. Since the last increase in our adits, we have not only got our supply in less time, but we are getting the well at a higher saturated level; and we who are engaged in the work feel satisfied that so long as there is rainfall, we shall get a supply of water for Leamington which will be second to none in the country.

The PRESIDENT: I should just like to remind you that we have visited other works besides the waterworks, and we shall be equally pleased to hear any remarks gentlemen may wish to make upon those works. When the Association visited Leamington many years ago, a paper was read on that occasion on the sewage works which we have seen to-day. It may be interesting to some of the members who were not then present, and who have no knowledge of our previous proceedings, if remarks respecting these works were made by some one on behalf of the authorities, or by those who know most about them. I myself asked what the extent of the land upon which the sewage is pumped was, but I did not get any answer. I believe the Chairman of the Highways and Sewerage Committee is present, and I should be glad if he would make a few remarks on the subject.

The BOROUGH SURVEYOR: The farm belonging to the Earl of Warwick on which the sewage of Leamington is disposed of by irrigation, consists of 375 acres. It is worked on the intermittent, downward filtration principle, one portion being worked one time, and one another. The soil is of a porous, sandy description, admirably adapted by nature for the purposes of filtration, having also most fortunately a clay bed about six feet below the surface. The effluent water passes off remarkably clear, and apparently so pure that some enthusiasts have been known to drink it. I cannot say that I have tasted it myself, but I can bear testimony that it is perfectly free from any odour, and also quite bright and clear. The farm yields heavy crops, and it would be a much more profitable concern if there were an easy way of getting rid of the produce it yields. They do, however, sell so much that it is a success and really pays. Some time ago there was a discussion between Lord Warwick and the Corporation, as his lordship desired to have the 450*l.* per annum he was paying for the sewage reduced. The farm books were sent over here for inspection, and those who were versed in these matters were of opinion there was a profit shown. Lord Warwick's agent argued the reverse, but in balancing the profit and loss account, he allowed nothing for the handsome salary paid to the farm bailiff, or for the almost ducal style of farm buildings. These were entered as loss; hence the discrepancy between the two estimates. There is no doubt of the farm being successful, both as a means of filtering the sewage and also financially.

Alderman WACKRILL, J.P.: I can give my testimony in favour of the remark made by Mr. Pritchard, that I really think the driving of adits would be a far more useful method of searching for further supplies of water than sinking the well deeper. The reason I give for that is, that in the new red sandstone in which the well is sunk, the water seems to be shut up in very limited sections. Although the area is very great,—it extends from our water works certainly as far as Coventry, a distance of many miles,—it does not necessarily follow that we collect water from the whole of that enormous district. When the larger well was being sunk, the water stood in the smaller shaft, only a very short distance away, the whole of the time the larger well was being sunk to a depth of 112 feet, without being drawn away in the slightest degree. This showed that within a very short distance the water was shut up in sections—that was to say, there was some impermeable section or strata that prevented the water filtering from the one well to the other, although they were only a distance of about 50 feet apart. Hence I suggest that our best plan would be to drive adits in different directions through these sealed-up sections, until we find we have tapped an entirely new supply. There is further evidence in favour of this in the fact that at the Brewery, only a short distance away, they derive their water from precisely the same strata, and that we do not touch their supply, neither do they touch ours. This shows that, if we only extended our adits, we should be very likely to break into a new section and thus increase our yield. As to the sewage works, you will see how fortunate we are in having erected a suitable building, and having had in the first instance to deal with an engineer who has given us splendid machinery, which has been running ever since it was erected, with only the very slightest repairs. The cost of the engine, boiler-house, shafts, and tanks was 4,745*l.*; and there was an additional cost for engines and boilers of 4,750*l.* To this must be added, what I had nearly forgotten, 4000*l.* for the rising main to Lord Warwick's sewage farm. Through this main the sewage is pumped two miles, to a height of about 120 feet. We are not in the same difficulty with respect to our sewage that some of you may be. We have a contract with Lord Warwick to take our sewage for a period of thirty years from the present time, and for the sewage Lord Warwick pays us 225*l.* a year. This sum, deducted from interest on the capital outlay, and the cost of pumping, will show the actual cost of disposing of our sewage. It costs us about 2,000*l.* a year, after deducting the 225*l.* we receive from Lord Warwick, which is really about equal to a 3*d.* rate. (This includes cost of tank.) In this undertaking the neighbouring districts of Milverton and Lillington are allied with us. We are joint owners of the works and machinery. Milverton and Lillington have paid their proportions of the cost of the engines and buildings, which permanently belong to them as much as to us, according to their rateable value. Thus you see that neighbouring districts may agree to become joint owners of property and plant though they may not be within the same boundary.

Mr. T. **Walker**: I think the method of using the river water as we have seen to-day for street-watering purposes very interesting. The machinery is most suitable and excellent, and I was very much struck by it. If we knew what the cost was, we could find out whether a saving could not be effected, where water for road purposes has to be obtained from a water company. The water level or head at Leamington is about 60 feet down the well. A bore in each well meets with only partial success, and yet between the wells there was this large stream of water passing along a fissure in the rock. This seems to indicate that boring is not of much use in this strata. No doubt, if headings could be driven at a level where they could be easily kept dry, driving them is the way to increase the supply. I cannot speak from experience in sandstone rock, but I can of chalk. I have been sinking a well at Croydon, and we have driven headings half a mile in length, sometimes a long way without the slightest indication of water until a man suddenly stuck his pick into a fissure. We had almost determined to abandon the work before we came upon the supply. We had sunk the well 200 feet and driven some 300 yards without coming across more than 500,000 gallons a day, but by continuing we got 2½ million gallons. Still chalk and sandstone are two very different things. But it appears to me, if you sink boreholes 200 feet without success and afterwards find a large spring close to them and at a higher level, it is useless boring, and driving headings is then the proper thing. By driving headings you also make a reservoir, which enables you to store the water when the pumps are not at work.

Mr. **Vawser**: I did not intend to say anything, but the debate seems to have taken the direction of discussing the capacity of the yield of wells in sandstone. I just wish to add my experience to the comments made by other speakers. It is to the effect that the mere sinking of a borehole, or driving of a heading, does not contribute any large proportion of water to the town supply, unless you intercept some fissure, or fracture or fault in the stone. You may take it that, in different towns, the porosity of the stone varies considerably. In some towns water will draw towards the well from a distance of 300 or 400 yards, and in other places a quarter or half a mile may be the extreme distance. I think you may say, as a general rule, that in the red sandstone, water would draw towards the well for a quarter of a mile. If you will just work it out, you will find that the yearly supply of water to the town of Leamington will amount to about 6 inches of rainfall on the area of ground contributing to the existing well. I assume about one-third, or perhaps one-fourth of the rainfall would reach the sandstone, and therefore it would seem to show that the lowering of the water in the well, the lowering of the line of saturation as it has been termed by Mr. De Normanville in his paper, is really due to what you may call the deterioration of the natural water supply as it at present exists. My own impression is, from what has been said, that lowering the source of supply, by sinking the borehole some 20 or 30 feet lower than it is now, would simply prolong the time during which that deterioration exists. I concur with Alderman Wackrill and Mr. Bright, who advocate the extension of the wells by means of adits and headings carried a long distance; but the mere construction of adits or headings for 200 or 300 yards around the shaft will do very little good towards making the supply of water really permanent. What is wanted is to go half a mile or more away, so as to get into some new pastures. I can congratulate the town of Leamington on the very fortunate position in which it is placed for the disposal of the sewage. It is not all of us who are favoured with a nobleman in our neighbourhood who is prepared to take the sewage for twenty or thirty years, and to pay 225*l.* a year for it. The fact that you have such a nobleman here shows that you ought to be thankful for the mercies you enjoy. In my neighbourhood, if a piece of land is required for a sewage farm, the owner asks about five times as much for it as it is worth, and often contrives to get it. They frequently ask 500*l.* or 600*l.* an acre for land for sewage purification, and when you come to consider you want one acre for each 100 persons, it very soon amounts to a big bill for the local authority to pay. That you at Leamington can get rid of your sewage for a 2*d.* rate is highly satisfactory and a subject for sincere congratulation. I do not know the town of Leamington sufficiently to discuss all the matters named in the paper, but we have all heard of Leamington, and last night I was very pleased to see the principal street in the town lighted up by electric light. We shall, perhaps, hear something more about it. It is an excellent light, and I never saw a town lighted by electricity before to the extent that Leamington is. It struck me the pillars were exceedingly near to each other. They are only about 20 yards apart. It would be interesting to know what the cost of lighting the parade with electricity is, compared with lighting other portions of the town with gas. I think I ought not to sit down without adding my testimony to what Mr. Pritchard has referred to, and as a humble member of the Association, express our thanks to his Worship the Mayor for inviting us here to-day as an Association. I feel myself under an obligation to say this, because whilst I was President of this Association, Mr. Fell was exceedingly anxious that we should come to Leamington, and there was to a certain extent an appointment made. Even then, though he did not occupy any official position, Mr. Fell offered to entertain the Association. On behalf of those who may not have an opportunity of speaking, I may perhaps be permitted to thank his Worship for his hospitality to-day.

Mr. **Gamble**: I see a good many of the trees in the town supported by a single stake at an angle. I should be glad to know whether that answers for the protection of young trees, and if the wind affects them in any way by chafing. It is a matter I have considerable difficulty with in my district. Possibly the people of Leamington may feel greater interest in the trees, and protect them more than the people of Grantham are prepared to do. Have you had any accident yet from the concrete steps at the Town Hall being slippery? Many of us are troubled with concrete being slippery, but if these steps are perfectly safe for the people of Leamington, I have no doubt some of us will be anxious to try them elsewhere. Can the author also give us the capital cost, the number of stand-pipes, and the length of the mains for street watering?

Mr. **Carlton**: I should like Mr. De Normanville to explain what is the cost per thousand gallons delivered, and secondly, what is the cost of distribution, and how many stand pipes there are, and their distance apart? At Beckenham the stand pipes average about 600 yards apart, and the cost for delivering water averages 25*l.* per mile, and the cost of distributing it another 25*l.*, making the actual cost for street watering 50*l.* per mile.

Mr. **Parker**: There is one thing which has been lost sight of by a great many local authorities from one end of the country to the other, and I am sorry also to find many engineers are drifting in the same direction. We are now practically face to face with a water famine, and any step which can be taken to save the gross waste which is taking place must be of importance. The 29 gallons per head per day, which Mr. Pritchard has referred to, could, I venture to think, be very readily reduced in a residential town like Leamington, where there are no large manufactories, to about one half that quantity. One thing about which I should like to have some information is, as to the work of the waste-meter in use in Leamington. My experience has been limited to the use of Deacon's meters, and the Corporation have not crippled me at all, but have allowed stop-taps to be placed in front of every house, and a systematic inspection to take place in every part of the town where there was much waste. First of all, I divided the town of Hereford into seven districts, by a system of back-pressure valves. In one district the effect was, by proper inspection and supervision, to reduce the consumption at once from 52 to 30 gallons per head. In another district the reduction was from 45 to 22, and in a third from 38 to 18. The total reduction, so far as it has gone in the four districts out of the seven, has been from 830,000 gallons per day per head to under 600,000. If gentlemen would direct their energies a little more in the direction of saving water instead of searching for fresh supplies, it would be far better. Water sheds are limited, population is increasing, and boring is expensive and uncertain; for this reason it is most essential in many cases that waste should be prevented. With regard to the sewage, the Corporation of Leamington, and those who negotiated the arrangements with Lord Warwick, are in a unique position, in being able to dispose of the sewage of the town, including interest on capital and working expenses, for a 2*d*. rate. In most towns it is equal to a 6*d*. rate, and in some places runs as high as 1*s*. Leamington seems to be fully abreast of Bath, Cheltenham, and other places, as it very properly should be, as a residential town.

The MAYOR: I should like to say one or two words. It has gratified me very much that the discussion has taken the lines it has done to-day. More particularly have I been gratified, because the discussion has borne out what several of us advocated a few years ago—the driving of adits for the purpose of increasing the water supply of the town. I differed at that time from the borough surveyor as to the method of obtaining water. I differed with him in the cost of his estimate, and I always thought he made a mistake of a 0 in his estimate. I think the deepening of the well, whilst the pumps were at work, would have been such an expensive matter, it would have been almost impossible to have carried it out. We should have had to strengthen the well and put in new girders, and I remembered the cost incurred by the Corporation some little time before in freeing the neighbourhood from vibrations. Nothing has been said about that, but some four or five years ago the vibration in the well was so very great that it was necessary to make extensive alterations. This was effected by putting in two concrete piers 26 feet deep, and 12 feet by 9 feet horizontal section. The bed-stones were carried on the concrete piers, and the iron girders are placed upon these, and in this way we have minimised the vibration. When a suggestion was made to disturb the bottom of the well, I thought it would be, from a constructive point of view, a mistake, and that we should not get the supply we are getting from the adit. We proposed that there should be an adit 100 yards long. This we afterwards greatly increased, but, if we were going to drive new adits, I should like to take them all through on the same level. By this means we should get the maximum amount of storage room. Those who have not been associated with us in the work have no idea of the great economy there is in working where you can get large storage. In Leamington we have pumped the whole twenty-four hours to get 800,000 gallons of water; and now, with the storage going on at night in these adits, we get the quantity we require in something like eight hours. I am quite convinced that the supply of water is greater than the surveyor imagines it to be. I believe the increased supply from the adits is considerably more than 60,000 gallons. I watched the driving of the adits very closely, and went down the well several times, and I certainly think, if we could drive the adits in fresh directions, or extend the present ones for storage room, whilst we should provide storage room we should also gain a larger supply of water. You would be surprised at the difference of the quality of the stone through which we passed in driving the adits. I know in the adit which runs in a north-easterly direction, when we got to the end, the stone was of the densest character possible. It was as hard as a flint and as dry as a bone—white and dry, and absolutely no water came from it. A little while before that the adits passed through stone that was quite porous and full of fissures. So you can easily understand how, in the case of the larger and the smaller well, we had the water standing at a higher level in the latter until the adit was cut connecting the two. The storage room gained by the adits was most important, and made the well far more economical to work. I have only a word or two more to say, and that is with respect to the electric light. We have, in Leamington, made the experiment of lighting the town by electricity. It may be interesting to some of you to know that the cable comes through the streets, direct from the works, to the bottom of the Holly Walk, and we take the electricity into our houses without any trouble at all. Practically, the problem of supplying electricity from a given spot is quite solved. We had some difficulty at first, but there is now no difficulty at all. In shops the light is considered perfect. Some of the opponents of electricity think the street lighting is not so perfect as our friend Mr. Vawser considers it is, and say it is a miserable failure. I do not think it is a failure, but I think the lanterns are a failure. I think that is where the mistake comes in. Experiments are now being made by putting in larger incandescent lamps, and if you will look at them—one at one end of this building, and one at the other end—and at the lantern about 100 yards further up the street, you will see the great increase of light we get from a larger incandescent lamp with an improved shaped lantern. There are too many columns. It is a new venture for Leamington, and it has been to some extent an experiment. We are going to reduce the number, but do not take that for granted, as we are somewhat erratic in our proceedings. But we intend to try to reduce the number of columns one half, and to double the power of the light, and then I think the lighting will be a success. With regard to the actual cost, if you take a 16-candle-power electric light and a gas jet lamp burning 5 feet per hour, I can inform you this, that you will find the cost of the two exactly the same to the town. We are paying on the Parade 380*l.* for the whole lighting of the street for twelve months, including the renewal of lamps when worn out. I had hoped to have had the pleasure of taking you through the works to-day, but there seems to have been some little difficulty about it, as the company are erecting large storage batteries.

Mr. C. JONES: I can only say that I am pleased with what I have heard and seen to-day. As an old visitor to Leamington, fifteen or sixteen years ago, I can heartily congratulate the Town Council of Leamington and their officers upon the position Leamington occupies at the present time. We visit many towns at our district meetings, and it is not mere flattery when I say there are few towns which will bear comparison with Leamington. Of course it is peculiar in many respects. I have been very much interested respecting the water supply. With respect to the electric light, I am very pleased with what I have seen, but I should like to know more about it, because I know some members are here to-day with the special object of advising their authorities respecting the electric light. I was very pleased to see in the *Morning Post* of this morning, a short article on the bill which was in the House of Lords last night—Lord Thurlow's bill for the removal of those clauses which have prevented the profitable investment of capital in connection with electric lighting. These clauses are to be removed, and a 42 years' term substituted. Consequently, from the present day I look forward to a great incentive being given to work out the problem of the electric-lighting question. I have no doubt, in the next two or three years, we shall learn more of the electric light, and of the best means of dealing with it, than we have ever known before. There is no doubt that the Board of Trade's regulations were so restrictive, that capitalists would not invest money in the electric light. Now that the time is to be extended to 42 years, there will be no further difficulty so far as money is concerned. I am very much pleased with what I have seen as to the sewage. Still, that is a thing you would not expect me to touch upon. I could not agree with the figures quoted, and should like to criticise them somewhat if there was time, and put a few questions to ascertain what the actual cost is, and whether the game is worth the candle. I should like to know, for example, what is the exact cost of delivering the sewage to Lord Warwick, and what you get back in return. These would be two very interesting sets of figures—the expenditure on one side and the receipts on the other. Alderman Wackrill omitted from his original estimate one little item of 4000*l.*, the cost of the rising main. That one item of 4000*l.* at 4 per cent., repayable in 30 years, at once gives me an item of 220*l.* a year. If you add this to other charges, possibly you might not arrive at quite such a satisfactory result as has been stated. But we have said many times that you must pay to get rid of a nuisance, and Leamington apparently gets rid of the nuisance of its sewage by the existing arrangement. When we met here some years ago, I remember Mr. Pritchard showing me some monster mangel wurtzel growing on the farm. Half-a-dozen of them filled a tumbril cart, or something of that kind. I remember him showing us one that was growing 3 feet out of the ground, and how far it went down I do not know, and no doubt it was good to the core. There is a difference of opinion about that, however, as you know. Still, the question of the purification of the sewage is an important one. It has been hinted that some of us have developed rather peculiar views on this question. I do not quite agree with Mr. Vawser when he says it requires one acre of land for every 100 persons; I would rather put another figure on to it, and if you clarify the sewage first, you may put on another figure. I think the waste of public money on the land may be looked upon as one of the illusions created by our friends in London, who told us many years ago that the sewage was to be a mine of wealth, out of which we were to draw enough to meet all our rates, and pay all the outgoings of a municipality. That was a dream, and something to be forgotton. We have started upon a new course of things now, and I trust that the meetings we have held within the last 15 years have had something to do with the sounder views now entertained. We cannot get a body of men, such as is here to-day, interested in this question, without some substantial good resulting from it. I congratulate Leamington on having a Mayor who has invited the Association to visit this town, and asked us freely to express our views, and assured us our criticism will be taken in good part. I also congratulate the town on having such a borough engineer as Mr. De Normanville, who can produce such an able paper as we have heard to-day. I trust they value him accordingly.

Mr. J. S. **Baly**, Medical Officer of Health: I can only, Mr President, speak of the quality of the water supply as shown by the health statistics of the borough. The town has a very low death-rate, and is extremely free from zymotic disease. In fact there was not last year a single death from typhoid fever in the whole of the borough. When a large part of the town was supplied with water from private wells, there were on the average eight deaths per annum from typhoid; but during the last five years there have been only four deaths from this disease, and several of these occurred amongst people who came from outside the borough. The death-rate last year from all causes was but 15·5 per 1000.

Mr. **Pritchard**: I fear I have not been clearly understood. When Mr. Baldwin Latham and I inspected the water works, we came to the conclusion that there was an abundant supply for Leamington, but that the health statistics of the town would soon prove whether it was pure or impure. We said so, because it was at that time publicly stated that the wells in different parts of the town, some at considerable distance from the pumping station, were being drained off. It was also stated that wells were being closed, by order of the magistrates, in consequence of the impurity of the water obtained from them. What I wished to convey was that, although since that date I have been perfectly satisfied of the purity of the water—as I know from the analyses of Dr. Tidy and other eminent chemists—I only pointed to the fact that we predicted in 1876 or 1877, that the Medical Officer of Health himself would soon prove by such statistics whether the water was pure or polluted. I may say I have held the opinion that the theory we then formed—a very reasonable theory if all the circumstances are fairly considered—has been disproved by the health of the town and the low death-rate.

The **President**: I think I shall now be obliged to close this discussion, and in doing so will endeavour not to say very much, because the whole subject has been so completely covered by previous speakers. One thing has struck me forcibly, and that is the unanimity of opinion which has been expressed in favour of any extension of the water supply being by means of adits, as against the theory of the Borough Surveyor in favour of sinking the well deeper. It is not very often that the members of this Association meet in any town, to discuss papers read, or the works executed or in prospective, where they find themselves with anything like the unanimity we have this afternoon in variance with the views of the local surveyor. I remember one or two cases where the greatest possible caution was exercised in differing from a gentleman who had had all the facts before him for a considerable time, and who was undoubtedly better able, with his full knowledge of all the local circumstances, to form a correct opinion than gentlemen who came to the town simply for a day or two, and formed their opinions from a cursory inspection of the works and plans. It is, however, not impossible, or any unusual thing, that when you call in an expert, he at once spots something the local man has failed to see. As a rule, I am quite sure the members of this Association will always be extremely cautious in expressing any opinion on a subject which has received such careful consideration on the part of the local surveyor. On the other hand, when these opinions have been formed even on a day's excursion like this, we have been accustomed to have the courage of our opinions and to express them. I must say, from what I have gathered from those who have expressed their views, that I incline to the theory of those gentlemen who have spoken in favour of adits. Mr. Vawser goes further than some of the others, and says you may extend the area from which you draw the water by the extension of the adits at the bottom of your present well, and that you will probably do so with better results than by deepening the well, which has brought difficulties elsewhere. But, in addition to this, it was a question of area. You will undoubtedly get on for a time only by extending your adits from your present wells. Eventually you will have to sink other wells on maiden ground, and extend adits to them, or place them at such a distance as to be able to connect them with the existing adits. I think, after the information which has been given by Mr. De Normanville respecting the fissures in the rocks, it would be the proper course to extend the adit in the direction of that fissure from which the principal supply is obtained. I am sure Mr. De Normanville will excuse the gentlemen who have expressed opinions differing from his own, and I am sure we shall all be pleased and glad to hear any argument Mr. De Normanville may have to advance to disprove the theory which has been advanced in opposition to his this afternoon. There is no doubt he has a theory of his own, and it may be instructive to hear what he has to say in support of it. I am sure he will take what has been said in good part. I think Leamington is to be congratulated on the excellence of the works we have seen so far as they have gone. I rather differ from our facetious friend, Mr. Jones, when he expressed surprise at the omission of the sum of 4000*l.* from the cost of the sewage works. I think, considering the size of the town, its importance and extent—because it extends over a very considerable area as compared with the number of its inhabitants—that both the sewage and the waterworks are reasonably cheap. You will find very few towns indeed with 26,000 or 28,000 inhabitants, where they can say that they have executed water works and sewage works of so successful a character as we have seen to-day for the same amount of money. Mr. Parker, of Hereford, touched upon a point which is really of great importance to the whole country, and that was the waste in the use, or rather misuse, of water in large towns. We have heard from Mr. De Normanville and Mr. Parker, what has been accomplished at Leamington and Hereford respectively; by the introduction of Deacon's waste meters, the insertion of stop valves and stop taps, the waste going on in particular streets and houses has been discovered, with the result that the consumption has been reduced very considerably. I have no doubt Mr. De Normanville will succeed in still further reducing the consumption in Leamington, if he prosecutes his inquiries further. This prevention of waste is equal to expending a large sum of money for extending your supply; and that is the view local authorities should take of it. It is sometimes said Deacon's system was very costly; but what would be the cost of works to supply water equal to the quantity saved by this arrangement? He had no doubt the cost would have been 200 or 300 times more than the meters, or possibly even more than that. I am quite sure it would have been in the case of Leicester. Two years ago the Corporation of Leicester went to Parliament for a bill to extend our water works at a cost of about a quarter of a million of money; and it was predicted that, unless we succeeded with the bill, we should be entirely without water, or, at any rate, the inhabitants would have to be put on very short commons for the next two or three years. When the bill was lost, steps were taken to see what could be done in the way of reducing the consumption of water. The result has been most successful, not by means of the more expensive method of Deacon's meters, but by the other means mentioned by Mr. Parker. We have succeeded at Leicester in reducing the consumption, although it is a manufacturing town, to under 18 gallons per head, and 7 gallons of this is practically delivered to manufacturers. Therefore, we have the consumption for purely domestic purposes as low probably as in any other town in England. If it had not been for that, we should have been pumping nearly a million gallons of water more than we are doing at present, and our reservoirs would soon have been dry. Therefore, while at Leamington you may be desirous of looking out for fresh fields for an extension of your water-supply, I am sure that every town engineer would do well to devote more attention to the prevention of waste. With regard to the sewage works, I am very pleased to hear how highly favoured Leamington is in having a nobleman who will actually pay you for pumping the sewage to his land, and you are equally fortunate in having a large area of land for the disposal of your sewage. If time had permitted, we might have heard something more of Mr. Jones' theory; but I am rather surprised to hear that he entirely differs from your mode of disposing of the sewage. I think Leamington has no need to resort to any other system. The works themselves, so far as we have had an opportunity of seeing them to-day—of course we have not seen everything,—but as regards the engines and machinery, they are most excellent examples. The pumping-engines at the sewage works especially, considering the time they have been erected, are most excellent, and they are works you need not be ashamed of ten or twenty years hence, notwithstanding the advances which will probably be made in that time. I was also pleased to find that although you have only one screen to your sewage tanks, through which the sewage is admitted to your pumps, the engineer rarely had any trouble with the pumps. I may say this is rather an unusual thing with sewage works, and I know towns where they have considerable difficulty. That may be accounted for probably by the fact that Leamington is not a manufacturing town. That makes a very great deal of difference when sewage has to pass through pumps. I am sure every member of the Association who has been here to-day will be exceedingly pleased, not only at the manner in which we have been received, but also by the part which has been taken by members of the Corporation in the discussion, and the full information which has been given to us respecting the works we have seen. I think every one of us who may in the future have anything to do with sinking wells in stratas similar to that on which Leamington stands, will to-day have learned something that cannot fail to prove useful to him. I can only repeat what has been said before, that there is no single meeting of this Association ever takes place at which something may not be learned by the members. I entirely endorse what Mr. Jones has said respecting the very excellent paper which has been read by the Borough Surveyor. I think the town of Leamington is to be congratulated on having a gentleman of such intelligence and ability and who has favoured us with such an admirable technical paper. We shall, however, have an opportunity of expressing our thanks to Mr. De Normanville in a more formal manner before we close these proceedings. If he is at all desirous of reserving his remarks, and submitting them in a more extended form for the 'Proceedings' of the Association, I am sure we shall be glad if he will avail himself of the opportunity to do so.

The BOROUGH SURVEYOR: It is pretty evident, gentlemen, that my ideas are unique amongst engineers, with regard to the sandstone formation on which this town is built, or at any rate amongst the Members attending this meeting of the Association. First of all, I have been rather misunderstood in the term used, viz.

"Deepening the well." It means, in the ordinary acceptation of the term, deepening 30, 60, or 100 feet, but in this special case the phrase is misleading. I simply wanted to excavate the rock in one portion of the well 10 feet, and also the heading as far as the fissure which supplies the water we use. Our well forms a sort of sumpt, 3 feet below the level of the heading. We pump in droughty weather day and night, and the water flows along the heading from the fissure and falls into the well, forming a miniature cascade from which it is pumped, the pumps being kept constantly only just free from air. The water which comes in from this fissure is governed by the ordinary laws of hydraulics, and the quantity delivered depends upon the size of the aperture supplying it, and the head or pressure acting upon it. About eighteen months before the falling off of the yield experienced in 1886, the line of saturation stood exactly 10 feet higher than it did at the time we were so very short of water. When the water stood 10 feet higher —that is 40 feet above the bottom of the well—than it was in the summer of 1886, when we were short of water, the yield was at the rate of 1,500,000 gallons per day, because the aperture or duct through which the water flowed into the well, driven by a head of 40 feet, yielded that quantity. When the line of saturation, and thus the head, was decreased 10 feet, the yield from the same fissure fell to 800,000 gallons per day. Having studied the matter deeply, I came to the conclusion that, if by deepening to the extent of 10 feet a portion of the well and of the heading as far as, and following down the fissure, the water was allowed to flow from a point 10 feet lower down, the old head or pressure would be restored, and with it the old yield. But to make more certain, as it was a matter rather for a geologist than an engineer, unless he had had a large experience in well sinking, I wrote to the Geological Survey in London, thinking that Sir Andrew Ramsay was still Director-General. I received a reply from Mr. Edward Best, his successor, who advised me to apply to Mr. Henry Howell, who conducted the Geological Survey of this district, and who was then in Scotland. I did so, and forwarded Mr. Howell an elaborate report, and complete tracings of the well, and received the following reply:—

"GEOLOGICAL SURVEY OFFICE, EDINBURGH, *November* 17*th*, 1885.

"DEAR SIR,—I have carefully considered your letters of the 11th, 13th, and 14th inst., with reference to increasing the water supply at Leamington, and the facts you have stated as to the existing supply from the wells. I am of opinion that the plan you propose to adopt of deepening the present well 10 feet is practicable, and that by lowering the well and heading the old yield, which was given before the line of saturation was permanently lowered, may be restored. I am also of opinion that there need be no fear that by deepening the well 10 feet the present supply would be lost, if you keep within the water-bearing sandstone bed, and do not sink below the stratum on which it rests."

Many of the opponents of this scheme expressed doubts about what they called "knocking the bottom of the well out." You will see that Mr. Howell informs me the impervious stratum is 19 feet below the bottom of the well. Besides one bore goes down 220 and the other 240 feet from the bottoms of the wells, so that there is no fear of losing the present supply by merely deepening the well 10 feet. That is my authority, in the way of geology, for my scheme. I think you will see that, as the flow of water from a pipe is dependent on the area of that pipe, and on the head or height above it of the supply, so, when the yield from the fissure fell off, the size of the fissure remaining the same, the falling off was due simply to the loss of head or the decrease of height above the fissure of the supply. If by excavating the heading and well from the fissure to the pumps, the water was allowed to flow from a point 10 feet lower down, the old head or pressure would be restored, and with it the yield, inasmuch as the factors of yield, viz. head, or pressure, and area, would be the same as of old. That was the only deepening of the well I ever proposed. I would not have proposed to add a single inch to the bores, which are too deep already and yield no water. I simply wanted to sink the well and heading 10 feet, so as to draw, in dry weather, the supply from 10 feet lower down. This was in 1886, but it was decided to drive adits. They were accordingly carried out, and yielded an additional 60,000 gallons per day. That, however, was not at all what the Corporation wanted or expected, because the specification for the work bound the contractor to carry on the headings if the Corporation thought fit, until an additional 300,000 gallons of water per day were obtained. But we only got 60,000 gallons, and next summer we had once more to issue handbills begging of people not to waste the water, and actually to shut off the water during certain hours, night after night, a thing that had never been done in Leamington before. Therefore the cutting of the adits had not done much good in the way of increasing the supply. In sandstone rock, which was as dry as a bone, except here and there, it is purely a matter of chance whether you come upon a fissure or not. All the water we came upon in driving the headings was from the same source as that we were previously obtaining. We now draw it from half-a-dozen places instead of merely one, and we now get the 60,000 gallons per day extra, simply because the fissure before was not large enough to let the water come through freely. The cost of the headings was 850*l*., but the additional supply was not sufficient to prevent us being again in great distress last year. Finding that my plan for deepening the well was not approved of, I did not press it, but turned my attention to a much better principle, that of which the President and Mr. Vawser have expressed approval, viz. economising the water we already had, and endeavouring to prevent its being wasted. I therefore suggested to the Corporation the use of river water for the purpose of watering the streets, and the use of Deacon's meters to detect and prevent waste. The dreadful figure of 29 gallons per head per day, mentioned by Mr. Pritchard, was only attained, just at the end of a season of three weeks' drought, when people would water their gardens and lawn tennis grounds, totally regardless of the interests of the town. The ordinary consumption of water in Leamington in summer is 25 or 26 gallons per head per day; but now, since the introduction of Deacon's meters, it has sunk as low as 16 gallons in March and 17 in April. The consumption of water is now increasing slightly, and although we have been reducing waste, we have to contend with the difficulty that the use of the water is increasing owing to the season. Last month the consumption was 17 gallons per head per day, and that compared very favourably with the corresponding month of last year, when the consumption was 24 gallons per head, calculated on precisely the same basis. With regard to the fear expressed by Mr. Pritchard in the past, as to the contamination of the water-supply by percolation from the surface wells in the town, I do not think such an anticipation was well founded. Leamington draws its supply from 100 feet below the surface, and the intermediate strata consist of sandstone rock and marls, so that any water percolating through from the surface wells, must pass through nature's own splendid filter and thus be thoroughly purified. Several questions were asked of me, to which I will briefly reply. One was whether there had been any accidents from the concrete pavement at the Town Hall. I have not heard of any myself. It is termed granolithic, and I think as regards slipperiness, is much the same as other concretes. The single struts or supports for young trees are not of my designing. They were in use when I came to Leamington. As struts or ties they can, of course, only work in one plane, but they answer their purpose satisfactorily.

The **President** proposed a vote of thanks to Mr. De Normanville for his excellent paper; and it was accorded by acclamation.

A vote of thanks to the Mayor and Corporation for the use of the Town Hall was also passed, and was acknowledged by the Mayor.

This closed the proceedings, and the Members, by the invitation of the Mayor, lunched with his Worship at the Crown Hotel.

The Members visited the Water Works, where the machinery was inspected, and some of the visitors descended the large well, the shaft of which is lighted by gas. The Mayor then conducted the party, through the Jephson Gardens, to the pump-rooms, where the new saline baths were examined, and also the machinery and arrangements for pumping water from the river for street-watering purposes. The sewage pumping station, at the west end of the New River Walk, was also visited, and then the party returned to the Town Hall to discuss the paper and the visits. In the evening the Mayor entertained the Association at the Crown Hotel.

DISTRICT MEETING AT YORK.

June 9th, 1888.

Held in the Council Chamber, Guildhall, York.

Joseph Gordon, *President, in the Chair.*

The Lord Mayor (Mr. Alderman Rymer) representing the Corporation and citizens of York, in a brief speech gave the meeting a hearty welcome to the city, to which the President replied.

A letter was read from Mr. J. W. Horsfield, stating his wish to resign the District Secretaryship, and Mr. Mawbey was then unanimously elected to succeed him.

After visiting the works and places of interest in the city, the following paper was read and discussed.

MUNICIPAL WORK IN YORK.

By E. G. MAWBEY, Assoc. M. Inst. C.E., City Surveyor, York.

Since your last meeting here in 1882 the city has made great progress, and it may fairly be said that at the present time almost unsurpassed efforts are being exerted by the various Committees of this Corporation in their different capacities to win for the city a reputation for modern municipal and sanitary work as well as for commercial enterprise worthy of its glorious fame as an honoured and loyal city and county in itself, with its Lord Mayor for 500 years past, and its numerous other important functions.

At the time of your last visit the population within the municipal boundary was about 50,000, the area 1971¾ acres, and the rateable value about 182,000*l.*; but in the year 1884 the Corporation went to Parliament for an extension of their boundary and for other necessary provisions, and succeeded in obtaining a Bill known as the "York Extension and Improvement Act, 1884"; consequently the estimated population is now about 71,000, the area 3553½ acres, and the rateable value about 236,158*l*.

In 1882 Mr. Styan enumerated to you the several important works he had designed and carried out for the city during the many years he had acted as city surveyor, and it was during his term of office that the Extension Bill was fought for and won.

The author commenced his duties here as city surveyor on the 4th of June, 1887, being elected on the second of the previous month, and will endeavour to give an account of this first year's work and experience in York.

REORGANISATION OF STAFF.

Much time and consideration has been bestowed upon the reorganisation of the various branches of the surveyor's department, and in working out and carrying into effect, as far as possible, the many details involved in adopting a thorough and satisfactory system.

BUILDING INSPECTION DEPARTMENT.

There are two building inspectors. During last year plans were passed for 260 houses, of which 254 were completed, and at the date of the report 156 were in course of erection.

Alterations and additions were made to 48 houses, about 60 other buildings were completed, and 22 were in course of erection.

345 works of a structural nature were also carried out under this department for the abatement of nuisances or the improvement of sanitary arrangements, and in all about 6400 inspections of works, &c., were made by the building inspectors during the year.

SANITARY DEPARTMENT.

The Corporation are fortunate in possessing as chief of the Sanitary Department such an able and indefatigable Medical Officer as Dr. North, whose work and reports are so thorough and exhaustive that I could not do justice to them in this paper.

There are two sanitary inspectors, and during last year 1745 various works for abatement of nuisances, &c., were carried out, which number includes the 345 above mentioned as being superintended by the building inspectors.

In all cases where structural works are necessary, the matter is referred to the city surveyor.

The building inspector makes a rough sketch plan of the premises, and, where necessary, tests the drain with the asphyxiator, and his report together with that of the sanitary inspector, and in many cases also a report from the medical officer are considered by the city surveyor, and recommendations made thereon. With our Improvement Act, powers were obtained for rendering the notification of certain infectious diseases compulsory on the householder as on the medical attendant, and it works extremely well. It enables the Medical Officer to report weekly on premises infected by disease, and the necessary steps to be promptly taken to prevent spreading and recurrence as far as practicable.

BYE-LAWS.

The Streets and Buildings and Sanitary Committees, with the assistance of the town clerk and the author, have drawn up new building and other bye-laws, which are the model bye-laws of the Local Government Board somewhat modified, and these have been deposited with the Local Government Board for their confirmation.

SCAVENGING.

The whole of the street watering and street scavenging is done, and all house refuse from movable receptacles is removed by the Corporation staff, but up to the present time the removal of house refuse from fixed receptacles, and the night soil has not, with the undermentioned exception, been undertaken.

Under the advice of the medical officer, during the summer and autumn months, in localities affected or threatened by infectious disease, the Corporation undertake free of cost to the owners and occupiers the removal of night soil and house refuse, the sweeping of the yards and the flushing and deodorising of the private drains as well as of the sewers.

The author has prepared a report and estimate for undertaking the domestic scavenging, and recommended that, to commence with, a Fryer's four-cell patent refuse destructor with Jones's fume cremating chamber be constructed at the Foss Islands Depôt. He estimated that, roughly speaking, after allowing for the probable revenue to be derived from the sale of manure and the produce, &c., from the destructor, the additional expense over the cost at present incurred in domestic scavenging would be about 3000*l.* per annum, which included the repayment of principal and interest of the sum of about 7000*l.* required to be expended in additional new stable buildings, plant, and the destructor, &c., which represents rather more than a rate of 3*d.* in the pound.

The Council have referred this matter to the Streets and Buildings and Sanitary Committees for joint consideration.

The author will be pleased to hear remarks from you respecting the desirability of this work being undertaken by Local Authorities and upon the disposal of house refuse.

CEMENT PAVING.

Portland cement concrete paving has to some extent been adopted during the last twelve months. It is laid 2½ inches thick on a bed of dry hard rubbish 4 inches thick.

The bottom layer is 1¾ inch thick, one part of Portland cement to three parts of granite gravel or crushed furnace slag with the dust left in and passed through a ½-inch screen. The top layer is ¾ inch thick, one part of Portland cement to two parts of granite gravel or crushed slag with the dust left in and passed through a ¼-inch screen.

The paving is laid *in situ* in alternate pieces 2 feet wide and the width of the footway. The first pieces are laid to wood screeds, and the intermediate squares filled-in in about thirty-six or forty-eight hours.

The wood screeds being removed, all the joints in each layer are cut through with a proper tool the whole depth of the concrete, and so far no defects have become apparent.

The cost, including foundation, has been about 3*s.* 6*d.* per yard laid complete.

WOOD PAVING.

There is at the present time about 9116 yards of wood paving laid down.

The first laid was in 1876 by Messrs. Armstrong, Addison, & Co., with creosoted fir blocks six inches deep laid on their own system on a bed of concrete.

Although this pavement has been laid for nearly twelve years the repairs have been very slight, and it is by no means yet worn out, and the blocks are as sound as when laid.

The bulk of the remainder of the paving, before the author's time, was laid with fir blocks varying in different places from four to six inches deep on a bed of concrete, chiefly on the system of Mr. Geo. Walker of Leeds.

In this paving the blocks were simply dipped in creosote, and although the work was well done the paving has in many instances become very much worn, in some places where it has only been down a comparatively short time, and this seems to point to the fact that in York, where the traffic is light compared with some towns, it is desirable to properly creosote the blocks as was done with Messrs. Armstrong, Addison, & Co.'s paving, as the wood blocks (if creosoted) seem to stand the York traffic for a much longer time than they last before decay takes place when not creosoted.

The paving now adopted and recently laid down in Market Street is 4½ inches deep, and that in Low Ousegate 5 inches deep of Wyburgh red deal properly creosoted with 8 lb. to the foot cube.

The blocks are laid on a layer of sand ⅜ inch thick on a bed of Portland cement concrete 6 inches thick.

In each block three cast-iron studs are driven, made by Messrs. Nettleford and Sons of High Holborn, as adopted in parts of London and at Leicester.

The joints are first run in with asphalte to a depth of about 1 inch, then racked in with fine crushed slag with the dust taken out and run with asphalte to within about 2½ inches of the surface, and finally grouted up with Portland cement and washed sand in equal parts and covered with a top dressing of fine gravel or crushed slag.

Expansion joints on each side of the street at the kerb are formed.

Mr. Walker is doing this work, and his contract price is 7*s.* 11*d.* per yard, exclusive of the foundation which is being put in by the Corporation staff.

PRIVATE STREETS.

The extension of the city boundary has at the present time necessitated the putting in force of the 150th section of the Public Health Act 1875 for the making up of private streets to a considerable extent, which as you will imagine greatly adds to the work of the surveyor's staff.

Great improvements to the streets are also being carried out by the Corporation in the added area, for which a loan of 20,000*l.* has been obtained.

STREET IMPROVEMENTS.

The Streets and Buildings Committee are negotiating for the widening of Skeldergate, Gillygate, and Holgate, and at their meeting on the 22nd ult. recommended the Council to authorise the purchase of property and lands required for the widening of Skeldergate at a cost of 7900*l.*, which is now confirmed by the Council.

SEWERAGE AND SEWAGE DISPOSAL.

Section 39 of the York Extension and Improvement Act 1884 enacts that the Corporation shall within two years of the commencement of the Act cause to be prepared a scheme for the efficient drainage of the city and the disposal of the sewage, and shall obtain the necessary powers from the Local Government Board or Parliament, and then forthwith proceed to put the same into force.

A few months before the author was appointed, Mr. James Mansergh, C.E., of Westminster, was engaged by the Corporation to prepare a scheme which has been submitted to them in alternative suggestions, one scheme estimated to cost about 106,000*l.*, and the other about 123,000*l.*, and the author has recently by an amicable arrangement been associated with Mr. Mansergh in this matter. The Corporation will doubtless shortly apply for the necessary powers to carry a scheme into execution.

BAR WALLS.

The city walls are now being restored under the supervision of the author.

The contract has been let to Mr. Joseph Clarke, of York, for the sum of 3254*l.*

The general drawings were prepared by Mr. George Styan when city surveyor, in accordance with the suggestions of Mr. G. T. Clark, an eminent antiquarian. The specification and bills of quantities were prepared by the author.

By carrying out this work a public promenade will be formed and opened out on the walls from Monk Bar to Bootham Bar, a distance of about 650 yards.

The parapets where now plain are being crenelated as of old, the bastions raised, crenelated, and loopholes formed therein, and a new bastion erected at the north-west angle of the Lord Mayor's Walk, on the site of an ancient bastion.

The old stones are being preserved and used again for facing.

A footway where none now exists is being constructed inside the walls on the top of the rampart with stone piers and arches and flagged floor.

COVERED MARKET.

The Council at their meeting on the 28th ult. approved of the recommendation of the Markets Committee for the erection of a new covered egg and butter market, according to the author's designs, at an estimated cost of 3000*l*.

BOROUGH COURT CELLS AND LAVATORIES.

Alterations and additions to the Borough Court within the Guildhall and the erection of police cells and lavatories in the Guildhall yard, designed by the author at a cost of about 1200*l*., are to be immediately proceeded with.

ALTERATIONS TO THEATRE.

The Council have also adopted the recommendation of the Estates Committee for carrying out the suggestions of the author for the necessary alterations to the theatre, to provide improved means of exit by additional staircase accommodation, &c., and for fire-extinguishing appliances. The drawings are now exhibited, and the specifications and bills of quantities are being prepared. The cost is estimated at 1520*l*.

MUNICIPAL OFFICES.

The committee appointed by the Council are considering the question of the erection of new municipal offices, and the author has prepared alternative preliminary plans showing the accommodation required on each floor, and has prepared approximate estimates for the same.

POLICE AND FIRE-BRIGADE STATIONS.

The Watch Committee having approved of the erection of new police and fire-brigade stations on the Clifford Street site in accordance with the rough sketch plans of the author, and estimated to cost about 7000*l*., the Municipal Offices Committee recommended the Council to instruct the city surveyor to prepare plans of the proposed new buildings. It has, however, been decided, in consequence of the enormous amount of work in the author's department, that competitive designs be obtained.

DAY INDUSTRIAL SCHOOLS.

The School Attendance Committee are considering the question of the erection of day industrial schools.

NABURN LOCK.

A new lock which is now nearly completed, and which His Royal Highness Prince Albert Victor has kindly consented to open, has been constructed for the Corporation, acting as the Ouse Navigation Trustees, at a cost of about 10,000*l.*

The lock has been designed by Mr. John Fowler, C.E., of Stockton-on-Tees, assisted by his son Mr. A. F. Fowler, C.E., who has also acted as resident engineer.

The contractors are Messrs. Nelson and Son, of York.

FOSS IMPROVEMENT.

The author has prepared designs and estimates for the lengthening of the Castle Mills Lock and for works of dredging and piling in the river Foss at York, at an estimated cost of about 5500*l.*; and in February last the Foss Navigation Committee recommended that, in order to render the Foss more available for traffic, the whole of the author's improvement scheme at the above estimated cost be carried out, which recommendation was approved by the Council and ordered to be carried into effect; but subsequent to this order Messrs. Leetham and Sons, the principal users of the river, on reconsideration of their requirements, requested the Corporation to also widen as well as lengthen the lock in order to admit of larger vessels, and it was ultimately resolved that, having regard to the great amount of time and labour which the author will have to bestow upon the sewerage and other schemes proposed or contemplated, and to the fact that the services of Mr. A. F. Fowler will be available for the purpose now that the Naburn Lock is drawing near completion, Mr. Fowler should be employed as the engineer for this work, and this gentleman has prepared a scheme, but it has not yet been finally settled to carry out the work.

Local Government Bill.

The current municipal year has been marked by the introduction into Parliament of the Local Government Bill, which has engaged the serious attention, not of York alone, but of every urban and rural sanitary authority in England and Wales.

As a measure to provide a system of Local Government, the Bill appears to have met with general approval, but where it trenches upon the rights and privileges of municipal corporations it has been freely and adversely criticised by those affected.

To ourselves as engineers and surveyors the Bill is of interest for two or three special reasons. The field for employment will probably be largely increased by the constitution of the new county councils and the new district councils subordinate thereto. These bodies will require skilled assistance to enable them to exercise their functions, and inasmuch as it is proposed to delegate to the county councils many of the powers now exercised by Government departments, such as the Local Government Board and the Board of Trade, it will be necessary that men of superior attainments should be appointed as advisers in engineering and other technical matters.

The law with regard to the maintenance of main roads has not been hitherto regarded as satisfactory by surveyors in general, and the Bill as drafted would place many municipal authorities in a still more disadvantageous position.

In our own case the proposal to subordinate York (a county of a city for five centuries) to the county council, is felt to be unjust, as has been amply demonstrated by the town clerk and the city accountant, who have shown that to include York in the North Riding would be to make a city with four miles of main roads contribute on the basis of rateable value to the maintenance of 479 miles of main roads in rural districts, a small proportion only of which are used by local tradesmen, which might involve the annual contribution of about 1600*l.* by the city for main road purposes, in return for which we should receive a grant of only about 160*l.*, and that in the matter of transferred taxes York would hand over a surplus of 5000*l.* for the benefit of rural districts, whilst the larger towns of Yorkshire would retain larger surpluses for their own advantage.

The Parliamentary Committee of the Corporation, prominently headed by the Lord Mayor and very ably advised and aided by our town clerk, have, however, made out a case for York which, together with the influence of our city members of Parliament, will, it is understood, result in the city being made a county for the purposes of the Bill, a privilege which it is expected will be also accorded to all towns with a population of 50,000.

CREDIT DUE TO STAFF.

The author has much pleasure in mentioning that great credit is due to the several members of his staff for the indefatigable manner in which they have carried out his instructions, and for the extra time they have worked with him after office hours in order to get through the heavy twelve months' work set forth in this paper.

DISCUSSION.

The **LORD MAYOR**: As you have mentioned my name, Mr. President, I rise, because I expect obedience when I occupy the position you fill; and it is therefore my duty to set an example of obedience to others. But I did not enter this room with the intention of taking part in the discussion. I came simply with the intention of being a learner—to listen to those who have practical knowledge of a much more extended character than I can lay claim to myself, and who have had technical training for this special work. You have seen to-day in some measure the works we have in progress in the city, and it is from you, who have the requisite practical knowledge, that we, who belong to the good old city, should be pleased to hear criticisms and remarks. There was one little remark I noticed in the paper, though probably Mr. Mawbey may have corrected it. He speaks of the city having had a Lord Mayor for 500 years. That is certainly correct, but for hundreds of years before that there was a gentleman who occupied a similar position, but was only honoured with the title of Mayor. Our charter of incorporation goes very much further back than 500 years. It is just about 500 years since Richard II. dubbed the then Mayor of the city, Lord Mayor. You will have seen in the city, from the works in progress, that we are going ahead, and, for an old cathedral city, are showing an immense amount of life and enterprise. At any rate some of our ratepayers seen to be a little bit alarmed, and think we are inclined to go rather too fast. I believe they have initiated a Ratepayers' Protection Association, to act as a sort of drag upon us, and see that we do not spend money too freely. Those members of the Association who attended the district meeting held here six years ago will see for themselves a vast difference in the aspect of the city now from what it was then. I think the commercial aspect has improved; our population and our trade have also materially increased in the interval; and we think that our compliance with modern sanitary requirements has likewise improved. We are quite aware we are a long way behind the large towns. Although we have undertaken these important works, we feel there is still very much to be done before we can lay claim to rank with those towns that have gone in for the most improved sanitary appliances for preserving the health of the people. I allude more especially to flushing and ventilating drains, to having a destructor, and to undertaking the whole of the cleansing and the removal of night soil. None of these things, we admit, are dealt with in a satisfactory manner at the present time; but when you next pay us a visit, I believe you will see still greater improvements effected than those which have taken place since your last visit six years ago. I make these few remarks, in obedience to the call of your President, merely for the purpose of opening the discussion. I hope there will be no reluctance on your part in speaking, and that you will feel no diffidence about expressing your views. We do not ask for praise if we do not deserve it; we are never hurt by honest criticism, and any suggestions which you may make I am sure our corporation and our surveyor will be very pleased to receive.

Mr. W. G. Laws: As our time is very short, I will only say a few words upon one or two points in Mr. Mawbey's paper. Mr. Mawbey has not left much room for criticism, and therefore I am driven to give you some of the results of my own experience. I understand, from the paper, you are about to adopt in York one of Fryer's destructors. We have had one in Newcastle in operation for about eighteen months, and I can give you a little information respecting our experience as to its working. I presume, from Mr. Mawbey's paper, that this is your first attempt at collecting the town refuse yourselves, and that it has hitherto been done by contract. I have very little doubt, when you have fully established a system of collecting and disposing of the refuse yourselves, you will find it more economical, and that it will tend very much to improve the health of the people. The adoption of a destructor was almost forced upon us at Newcastle. The sale of our refuse as manure was much impeded by what we called the "shop refuse," and the material which was swept out into the streets in the morning, which has no manurial value itself, and when mixed with ordinary refuse renders it of less value to the farmers. We came to the conclusion that the best system of disposing of this was to destroy it by means of fire. We now burn between 40 and 50 tons per day, with the result that we get a better price for our ordinary manure, which we send by rail to farmers, and we get rid of what would be unsaleable as manure, and which was frequently put in old quarries and other places, and made a very bad foundation for new buildings. The cost of the destructor of course is considerable. We find on the average that the actual cost for labour is between 6½*d.* and 7*d.* per ton. If you add to that 5 per cent. upon the capital cost of the destructor, that brings the cost of burning up to something like 11*d.* per ton. In giving these figures, I have not added anything for the redemption of the capital originally expended. I do not think it is a fair way, where money is borrowed for 25 or 30 years, to add the cost of the actual redemption of the capital to the working expenses. They have to be kept in repair, and at the end of 25 or 30 years, although not so valuable as buildings, they are carrying on the same work. Therefore I think the best plan is to put on a percentage which will cover the necessary repairs, and so far as I can see, these expenses in connection with a destructor would be covered by an annual charge of 5 per cent. on the original outlay. We find that the material which we destroy contains quite sufficient carbon in it to burn itself; and we get as residuals, ashes, which are used largely in paving, and we get clinkers, of which we make concrete. I am sorry the sale for these residuals is not as large as we could wish. I am now putting into the sewers of the town concrete made almost entirely of the clinkers which we get from the refuse destructor. We have adopted the plan of keeping the destructor going night and day. It is somewhat hard upon the men who work it, and it costs a little more no doubt for labour; but we find that the more uniform you can keep the heat of these furnaces, the less damage there is from alternate swelling and contraction. At the end of eighteen months, during which time our fires have never been out an hour, our destructor is working just as well as ever, and we have not, to my knowledge, spent more than 30*l.* upon it in the shape of repairs. That gives us very fair promise for the future, but of course we do not expect the cost of repairs to be so moderate in future years. No doubt there must be gradual depreciation, but still we have every reason to believe that the outlay for repairs will be kept within moderate limits. As to the removal of refuse, which you are in York about to undertake, our experience in Newcastle is that it costs us a trifle under 2*s*. per ton for collection and removal. House refuse costs about 1*s*. 9½*d*. per ton; but street refuse, on account of the larger amount of labour in scavenging, costs considerably more than that, and the average is just under 2*s*. per ton. We have for some time, partly with a view of encouraging the water-closet system, and partly to avoid night work, been adopting the dry ash-tub system, which is attended to in the day. We supply householders with tubs, sufficiently large to hold three or four days' refuse from the house. These we collect between eight o'clock in the morning and six o'clock in the evening. We supply these tubs at a moderate cost—3*s*. 6*d*. each. One great point is that the collection, instead of being carried out at night, when entrance to premises was frequently obtained by men climbing over walls, is made entirely during the day. Thus any ratepayer who finds men in his yard after six o'clock at night now knows that they are not there by the authority of the Corporation. We have found that men caught in yards at night, have said that they were Corporation servants and were thus able to get away. By adopting the dry ashes system, we are able to say to householders, "If you find any persons in your yard after six o'clock at night, they are certainly not there by our authority." We find the public take very kindly to this box system of removal. We encourage people, as far as possible, to make their kitchen fires their own destructors, and to burn anything in them that would naturally be liable to decomposition, such as fish refuse, vegetable cuttings, and all that sort of thing. If they put them on a hot kitchen fire, more especially just after cooking is over, it has the effect of disposing of the refuse itself without any smell whatever, and of making the ashes that are deposited in the tub perfectly dry and inodorous.

Mr. J. Cartwright: I rise to say a few words respecting this paper, and the works which we have inspected to-day. Like the Lord Mayor, I came here to learn, and I have learned. I congratulate the City Council of York on having such an able and numerous staff for the enforcement of the sanitary regulations which they have established. I am very pleased to see that so much care is taken in the inspection of new buildings. In our

Lancashire towns, this is very much neglected, and we shall have much to do before we can persuade our several Councils to take a leaf from your book with regard to this matter. The question of the destructor, on which Mr. Laws has spoken, has often been before this Association. There is little new to be said on the subject, so I will only add a few words. It is rather a costly way of disposing of the refuse of a town like this, though you will no doubt find it much to your gain, if not financially, at least in the comfort and health of the inhabitants, if you undertake the entire removal and, if possible, the destruction of the refuse of the town. I visited York on the occasion of the meeting of the British Association, and I can bear testimony to the improvements which have been made, and are being made, in the footways and roads of the city. With regard to the wood pavement, I fail to see why the groove is left even for expansion, though I know it is the practice of many wood pavement companies, and people who have had experience. I say this after close observation for seven or eight years of different kinds of wood pavement, and in my own experience I have found no necessity whatever for this groove being left. Besides, these expansion joints left near to the kerb look unsightly. With regard to the concrete, with all respect to Mr. Mawbey, I venture to say that the concrete is not being left to harden sufficiently long before he commences the paving. I think he will find, if he looks carefully into the matter, it is rather too soon to pave the same day that the concrete is laid. I am pleased to see you are creosoting your timber, it must be of great utility, both as conducing to make it last, and from a sanitary point of view, that the pores of the wood should be well filled with creosote. With reference to the bye-laws. This is an old subject, and one which has rankled in our minds ever since the Models were sent out by the Local Government Board. Many of us are satisfied they are impracticable and not suitable for all towns; and we shall wait to see what success you have with the Local Government Board, with regard to any modifications you have made in your bye-laws respecting new buildings. I am sure from my own experience in this matter, that the Local Government Board have drawn too hard and fast a line. Doubtless it is very difficult to compile a code of bye-laws to suit all, still I think the Local Government Board might, to the advantage of some towns, relax somewhat with regard to some of these bye-laws. There is not time to go into detail, but it is acknowledged that some of them are impracticable. As we were passing along to-day, some gentleman called attention to the macadam which was being put down in private streets. We have the advantage of having with us to-day, not only many experienced engineers, but also a very able solicitor, the Town Clerk of York, and I have no doubt he will keep us straight on this point. I have been told that the Local Government Board hold it wrong for any sanitary authority to adopt a street as a public highway, unless it has been properly paved, kerbed, and channelled. We have no difficulty on this point in Bury, because we are in a stone country and the streets are all paved and flagged throughout. I can only add, Mr. President, that I am very pleased to be here to bear personal testimony to the improvements made in this city and to the able manner in which they have been carried out by the City Surveyor.

Mr. A. M. **Fowler**: There are just one or two words which I should like to say respecting Mr. Mawbey's paper. From the position and importance of York in the country, of course we shall all look forward with some interest to the result of their modifications of the model bye-laws of the Local Government Board. We know that the model bye-laws are very defective, and that what will suit London is not adapted for Lancashire or towns in Yorkshire. I think a great deal of the indefatigable exertions of your Medical Officer of Health will be thwarted unless you can get the model bye-laws to work without friction. It is quite certain they work with friction now, inasmuch as, however badly a house may be built—although it may come within the four corners of the building regulations—still you have no power to stop that house being inhabited. The roundabout way in which the bye-laws say you shall stop that house being occupied is very roundabout indeed, and almost impracticable. In many large towns, such as Manchester and Leeds, they have power to grant a certificate when a house is fit for occupation. If the city of York could get a clause introduced to obtain this provision, which other towns have acquired by Act of Parliament, I am sure that it would be a great advantage.

The **Town Clerk**: I am sure I may tell you that we asked for it, but were told that we could not have it.

Mr. **Fowler**: I know that some towns have this power, and some have not. There is another important matter with regard to York, and that is the sewage scheme. York is on the eve of an important work, and the development of that great undertaking will be watched with interest. Sanitarians have been going up and down the country, from London to Newcastle, developing sanitary measures and reducing the death-rate, but still some towns are going on in the old groove. We may take Rochdale, Nottingham, and Manchester as examples. I would just caution York by calling attention to Manchester. Manchester has just been holding a public meeting on sanitary matters, and after all its troubles and trials, Manchester was found to have the highest death-rate of any town in England. Its average death-rate was 27, and in some districts, it was said, as high as 40 per 1000. Manchester, like York, has a very large scheme of sewerage before it; and I would simply say, if at York you are going to carry out such a scheme with firmness, and without regard to expense, so far as the health of the people is concerned,—scavenge at one end of the sewer, not at both. The great fault in these large towns is that some "faddist"—some fluent member, who is flippant of tongue, and can catch the majority of the Council—gets his views adopted, and runs the town into expense, until it is nearly ruined by heavy rates. Nottingham has a great army of men, and carts, and horses, and all the sewage is manipulated in tubs and manufactured in the town. Think of the condition of the hundreds of men engaged in this work, and remember that they have to go home to their wives and families in their filthy clothes. Nottingham has a large scheme of sewerage, but they scavenger at both ends. They should scavenger at one end only, and the work should be carried on and done in such a way that it should be an example and a pattern for the district and the whole country. London in 1847 had the midden system. The authorities proceeded to order that all cesspools should be removed and done away with. What has been the result? Why, that London is the healthiest city in the world. I therefore cannot understand why Rochdale, Nottingham, and other places still go on collecting filth, and manipulating it in the town when they are going to have a large and modern system of sewage arrangements. I would simply throw out this hint to York, not to look at the statistics about the manufacture of this manure, but to take the death-rate of these places, and consider which is the best development of the Christian principles of the country. I have just one word to say about country roads. It has occurred to me that the County Surveyor, in carrying on his work, will perhaps have to quadruple his staff, in order to have complete inspection of the county roads, whereas, at the present time, he simply sees that the roads are repaired by the local surveyors, and certifies for the proportion to be paid for maintenance, without any extra staff.

The **President**: There are many points in Mr. Mawbey's paper on which much might be said. I think one thing is very clear at any rate, that since Mr. Mawbey entered upon the office of City Surveyor, the Council of this city have given him plenty to do. If you look over his paper, which embraces a period of about twelve months, you will see that it teems with work. There is, I think, evidence that Mr. Mawbey has been called upon by the Council to do more than might have been expected of him, and he has done it with his usual ability. There is the city wall restoration, at an estimated cost of 3254*l.*; the scheme for covered market, 30,000*l.*; the borough court extensions, 1200*l.*; the new municipal offices, and new police and fire-brigade stations, and lock and river improvements to the Foss. We all know what this means—these contracts in small sums; it means a very great deal of labour for the surveyor, and I am very glad to find there is such an amount of enterprise in the Council of the city of York. It is a great pity that we have not time now to fully follow up the various points which have been raised in Mr. Mawbey's paper. Allusion has been made to the presence amongst us to-day of a gentleman of legal learning, and, if the discussion had been continued, I am sure we should have been exceedingly pleased to have heard him on the 150th section of the Public Health Act. I notice, too, on my right, the Medical Officer of Health; and, had time permitted, I am sure we should have been equally pleased to have heard his views on matters connected with sanitation. I think the remarks of Mr. Fowler may have been misunderstood. I should not like a wrong impression to go forth, and I am sure Mr. Fowler would be sorry if that were to be the case. So far as I understand at present, with regard to the sewage question, York is not proposing in any shape to introduce the pail system. I understand that to be so, and that they are going to scavenge at one end, and at one end only.

Mr. **Mawbey**: That is so.

The **President**: Therefore Mr. Fowler's remarks respecting Manchester and Nottingham—and he might also have included Leicester—do not apply to the city of York. If he meant it merely as a warning to York not to think of disposing of the sewage in any way but by means of a thorough sewerage system, then he was probably right in referring to it in the way he did. Mr. Mawbey's paper is short, but he has made some statements respecting wood pavement, criticism of which I am sure will be taken in good part. There is one thing that struck me with regard to the wood pavement, which, as well as the concrete footways, I am exceedingly pleased to see so well carried out. Mr. Mawbey tells us that the contract price is 7*s.* 11*d.* per yard, exclusive of the concrete foundation which is being put in by the Corporation staff. I do not know what he estimates the cost of the concrete foundation at, but it seems to me that the total cost of the pavement would be very little short of 10*s.* per square yard. I do not know whose process it is; but at Leicester we can put down wood pavement, with a 6-inch lime foundation, for 7*s.* a square yard. At Leicester the wood is not creosoted, and that possibly may make some considerable difference. The cost of the concrete footways, 3*s.* 6*d.* per yard complete, is, I think, also quite enough, because in Leicester we can do the same sort of pavement at from 2*s.* 8*d.* to 3*s.* per square yard. It may be that we get cement a little cheaper than in York, but I do not know. These are points on which we are anxious to get the fullest information for our guidance in other towns. I dare not take up more of your time, or I should have liked to have heard Mr. Gamble and Mr. De Courcy Meade, both of whom had intended to speak, and also the Medical Officer of Health for the city. I dare not, however, infringe longer on the forbearance of the Lord Mayor, unless the Town Clerk can give us in a minute or two— and I am sure he will excuse my being compelled to cut him short — his views respecting the 150th section of the Public Health Act.

The TOWN CLERK (Mr. George McGuire): I have put my book away, and I thought you had absolved me from the duty of saying anything to-day. I think I may say that, as the legal adviser of one Corporation, I have my work pretty well set; I did not know that to-day I should be called upon to act as the legal adviser of the representatives of twenty or thirty other public bodies. I think, Mr. President, the remarks which have been made with regard to taking over highways, are justified by the existing state of the law. It is a state of the law which I cannot myself regard as satisfactory. We begin first with section 150 of the Public Health Act, which, as you are all aware, prescribes the manner in which local authorities may call upon property owners to make streets and sewer them. The wording of that section gives an alternative. You may require the owners to sewer, level, pave, metal, flag or channel; but, when you come to the 152nd section, which prescribes the mode of taking over a street which has been made—I use the general word "made" there—to your satisfaction, you are told that you have power to declare it a public highway when the street has been "sewered, levelled, paved, flagged, metalled, channelled and made good, and provided with proper means of lighting, to the satisfaction of the Local Authority." There you have the word "and," which is copulative, and takes these things altogether, and not the word "or," as in the 150th section, which would give you an alternative. I find it laid down in the books, that, in order to enable a local authority to declare a street not being a highway repairable by the inhabitants at large to be a highway so repairable by the inhabitants at large, it is necessary that all the works specified in section 152 shall have been executed in the street to the satisfaction of the local authority. That appears to have been decided in the case of the Attorney General *v.* Bidder and others. On the strength of that, and following that decision, the Local Government Board have said that local authorities have no jurisdiction to take over streets and declare them public highways unless all these things have been done. This was laid down, as I have said, in the case of the Attorney General *v.* Bidder, and it has been argued by some people, on the strength of this, that if a street were paved with wood it could not legally be taken over. Lumley, in his book, doubts whether this is good law; and I myself should doubt whether it is good, for this reason, that, according to that principle, a street must be completed, with all these requirements, in order to be taken over by a local authority. That is to say, it must be sewered, levelled, paved, flagged, metalled and channelled. Now, I say it stands to reason that no local authority would both pave and metal a street, and therefore, in advising my own Corporation, I have no hesitation in telling them to exercise their own discretion in the matter, and if they think a metalled or macadamized street is fit to be taken over and repaired by them, they may take whatever risk there is in doing so. I say this, moreover, for another reason, because the matter may be looked at in another way. There are cases in which a Corporation are very anxious to lay hold of a street and say it is a highway. I remember a case in Leeds, where an owner of property put up some sixty houses in a street. He might have put up sixty-two houses, but he put up two rows of thirty, with a gap between the two blocks of houses.

For a period of six or seven years he allowed people to cross over that gap freely, like any public street. There was no obstruction whatever to people passing through that gap; but, at the expiration of six or seven years, the owner wished to put up two additional houses. The Corporation said, "No, we claim that as a highway," and Mr. Bruce, the Leeds stipendiary magistrate, upheld our contention that even in such a short period as six or seven years, there was dedication to the public, and that being a highway, the Corporation had the right to claim it. I think that is an additional reason why you should take a common-sense view with regard to this matter, and not play fast and loose with property owners; but that where a street has been laid out in such a way that local requirements and requirements as to drainage and lighting have been met, it ought to be taken over. I think it would be very hard if, in a city like York, you required all streets, and especially small side streets, to be paved with granite before they were taken over as public highways.

The **President**: I have very great pleasure in proposing a vote of thanks to Mr. Mawbey for his very interesting paper, and I am only sorry we cannot devote more time for discussing it. But I am sure you will all wish to thank Mr. Mawbey most cordially in the usual way; and if he desires to make any reply, he will perhaps be good enough to send it in in writing.

The **City Surveyor**: I am glad to learn, from the remarks made by Mr. Laws this afternoon, that the water-closet system is being encouraged in Newcastle. I have done my utmost to substitute water-closets for the old-fashioned privies in York. I feel quite convinced, after taking into consideration all the objections raised against water-closets, that the system is after all the cheapest and best. In York, although we do not unfortunately undertake the whole of the domestic scavengering, we do remove, free of cost, domestic refuse from movable receptacles, whenever the owners will agree to abolish their abominable ashpits or middens. I quite agree with Mr. Fowler in his condemnation of the pail system. With respect to the remarks made by Mr. Cartwright, the first cost of our 5-inch wood-paving is increased about 13*d.* a yard super for injecting 8 lb. of creosote to the cubic foot; and we use cement concrete as a foundation for the paving. I am quite sure the creosoting pays well for doing in York, where it has lasted good nearly twice as long as the uncreosoted paving. In one or two other towns, where provision had not been made for expansion in wood pavement, due to the swelling of the blocks in wet weather, I have seen the paving raised off its bed, so that it appeared something like the ridges and furrows of a pasture. I have also seen kerbing and flagging lifted out of place in the same way. The reasons the blocks were laid before the concrete had become sufficiently hard, was, that in consequence of the street having to be used for traffic during the races, I was compelled to commence the paving sooner than I otherwise should have done, in order to show you the work in progress. With regard to the erection of new buildings, no drains or foundations are ever allowed to be covered up until they have been inspected. I must say I have gained very considerable experience and knowledge by availing myself of the advantages offered by this Association, and I trust that surveyors and sanitary engineers will not fail to recognise the claims such an Association has upon them.

Dr. **North** (Medical Officer of Health): I feel it an honour to be allowed to take some part in the proceedings this day, for I feel that a Society of Municipal and Sanitary Engineers and Medical Officers of Health have a common object and a common duty. I feel that they are both alike engaged in the philanthropic work of diminishing human suffering and prolonging life. I often feel that it would be well if sanitary engineers would make themselves more fully acquainted with the details of medical knowledge as to the cause of disease, and I am quite sure that medical officers of health would benefit very considerably if they made themselves more acquainted with the functions and duties of sanitary engineers. I think one of the chief aims of both should be, to attain, as far as possible, to perfect cleanliness in the vicinity of dwellings, and I cannot quite understand how it is that, in the northern parts of England, one finds men cling with something like affection to the old midden system. I think that those who defend the common midden privy are alike unmindful of the teachings of the Bible, of the construction and functions of their own bodies, and of the general objects of cleanliness. Let us hope that the day is not far distant when such unsanitary abominations will be altogether abolished. In reply to remarks made by the President, I think it is only fair to explain to this Association that the death-rate of York, which in 1884 was 21 to 22 per 1000, has since been lowered, from an extension of the borough boundaries. About the date named, a suburban population, whose death-rate was only some 18 per 1000, was incorporated into the city. Thus without any actual lowering of the death-rate of the city, the recorded death-rate was lowered to the extent of 1 per 1000 inhabitants.

The Members visited and inspected the wood-paving work in Low Ousegate, the working of the Skeldergate Bascule Bridge, the Restoration Works of the City Walls in progress, and other points of interest in the City.

DISTRICT MEETING AT CARLISLE.

June 23rd, 1888.

Held in the Council Chamber, Town Hall.

Mr. J. Gordon, *President, in the Chair.*

The Mayor received and very heartily welcomed the Association to Carlisle, after which the following papers were read and discussed :—

CARLISLE CORPORATION MARKETS.

Description of Central Main Roofs.

By A. T. WALMISLEY, M. Inst. C.E.

The new roofs now in course of construction in the city of Carlisle, cover an area of about 6300 square yards, exclusive of surrounding arcades, shops, and offices which are connected with the market buildings.

A length of about 197 feet 6 inches by about 211 feet 6 inches in width, forming an area of about 417 squares (of 100 superficial feet), is roofed over in three equal spans of 70 feet 6 inches each, supported by walls at Scotch Street and New Street sides, and by twelve intermediate columns, set out at distances of about 39 feet 6 inches apart, parallel to these streets. The central span of 70 feet 6 inches is carried round at an angle towards Fisher Street, so as to enter this thoroughfare nearly at right angles. This length is about 76 feet, and is enclosed upon one side by existing buildings, and upon the other side partly by a fish market covering 2370 square feet, or say 24 squares, and partly by a three-cornered roof of 600 square feet.

The main ribs of the roof covering the general market, are of the braced arch type, consisting of a rigid wrought-iron rib 13 inches deep in the centre, having a curved outer surface struck with a radius of 44 feet 6 inches, and forming a truss connected by round bar-iron ties having screw adjustments, the total depth from the back of the rib at the centre to the springing line being 18 feet 9 inches, and to the horizontal tie 11 feet 6 inches, which horizontal tie is placed 7 feet 3 inches above the springing line. The soffit to the curved member of the truss, is struck with three radii of 41 feet 6 inches, 58 feet, and 11 feet 6 inches respectively, the depth of the arched portion near the springing being 18 inches. The flanges consist of two 3½" by 3½" by ½-inch angle irons united vertically with a ⅜-inch web plate. The round bars in the ties are of scantlings varying in diameter from 1¾ inches to 2¾ inches, and in order to secure a proper connection between the inclined tie rods and the segmental rib at the springing, the feet of the principals at the junction of the rods are spread out laterally, the webs doubled, and the tie rods united to the curved member by pins of 4 inches diameter.

Owing to the unsymmetrical form of the plan of the roof, necessitated by the shape of the ground available for market buildings, special ribs were required in some parts of the design. Thus a special intersection rib had to be designed to be fixed at the junction of the central span with the continuation of that span towards Fisher Street; and at the end of the side span adjoining New Street, where it abuts against the fish market, special hipped ribs were introduced; but the whole of the ribs were designed so as to preserve harmony throughout, and to maintain a uniformity in the general appearance.

In order to avoid as little interference as possible with the space of the market, the number of columns was minimised by carrying alternate main ribs upon spandrel girders of 38 feet span, 4 feet deep at the ends, diminishing to 3 feet deep at the centre. These girders are fixed between the heads of the columns at a uniform level throughout, but owing to the levels of the adjacent streets, and in order to avoid the great inconvenience of steps to a market, the floor is made to slope towards one end, and consequently the height of the columns varies with the gradient of the market floor. The columns are of cast-iron 18 inches diameter, 1½ inch metal with brackets cast on, above the capitals, to suit the design of the main ribs. They average 28 feet in length, and are to be noticed as a successful adoption of an octagonal body developing into a square head and base instead of the stereotyped circular form. They have been made by Messrs. Cowan, Sheldon, & Co., and the author is very well satisfied with their execution. The lateral force of the wind upon the roof is transmitted through the main ribs to the columns, and the columns are rigidly fixed so as to provide the necessary reaction to resist it. By these means the side walls are left to take only their own wind pressure, and such portions as are communicated to them by any wind pressure which the columns may not take, but as nearly the whole of the horizontal force from the roof ultimately becomes transmitted to the columns, the eleven columns which come between Scotch Street and New Street had to be designed to resist this pressure. To provide a base sufficiently strong for this purpose, and also to facilitate the fixing of the columns as well as the drainage of the roof, the bases were cast separate from the columns, the faces at the horizontal joints being planed and securely fixed by eight 1½-inch bolts at erection. The bases, which are 4 feet 9 inches square, are each firmly bolted down by four 2¼ inches diameter anchor bolts, bedded and firmly secured to a cast-iron anchor plate, fixed in and below a mass of Portland cement concrete, 10 feet 6 inches square and 6 feet thick. The rain water from the gutters between the spans is conveyed down the column by wrought-iron tubes 6 inches diameter of 16 B.W.G. plate, between which and the internal faces of the columns, concrete is firmly packed, adding weight to the foundation, and forming a permanent protection to the columns from oxidation, by the continual passage of surface water.

The main purlins, which are carried by the main ribs, are 19 feet 9 inches long and are of lattice construction with parallel flanges, each flange being made up of two 2½″ by 2½″ by ⅜ inch L.I. Intermediate ribs are carried between the centres of the main purlins. They are also of the parallel lattice type, and are struck from the same centres as the arched portion of the main ribs. Between each main purlin, intermediate or secondary purlins will be fixed so as to divide the roof into convenient dimensions transversely as well as longitudinally for boarding and glazing. The secondary purlins are of a fish-bellied lattice type, 9 feet 10½ inches long, with a depth of 12 inches under the boarded and slated portion of the roof and 9 inches under the glazed portion. The glazing bar to be used is known as Helliwell's King's Cross bar. Helliwell's system has been employed by the author in the large roof over Olympia at Kensington, and has (the author is informed) been previously used in Carlisle in the roof connected with the Corporation Baths. Each span of the roof will be surmounted by a skylight carried by central ornamental trusses 22 feet span, placed

9 feet 10½ inches apart. Between the skylight and the curved roof, vertical louvre frames are provided, filled in with wrought-iron louvres. The lower portion of the curved roof, and also the lower portions of the skylights are to be covered with slates on 1¼-inch boarding, and the remaining portions are to be glazed.

The three spans of the roof at the West Tower Street end of the general market, rise above the buildings, and are therefore to be closed in with gable screens of a special design, suited to the character of the building. Two of these screens are complete segments, but the third is cut into, by the Tower at the New Street corner, necessitating a modification of the detail in the half span. In the design of these screens the author has avoided the heavy parallel members usual in screens for large roofs, and has introduced vertical triangular trusses having their bases connected to a horizontal bowstring shaped girder. This horizontal girder is 4 feet deep in the centre, and is trussed upon the inside so as to obtain lateral stiffness at the support of the vertical trusses. It not only acts as a tie to the feet of the screen rib, but supports a lead flat upon the outside about 14 feet in width. In resisting the lateral pressure of the wind upon the screen, the glazing is prevented from being blown in, by horizontal angle irons, supporting at intervals the glazing bars, and fixed to the vertical trusses placed 7 feet 1 inch apart, which act as ties to hold up the horizontal girder. These vertical trusses having at their base the same depth as the ordinates of the fish-bellied horizontal truss, which is fixed at the level of the springing of the main principals, gradually taper off as they approach the end arched rib, and thus the effective depth of the screen varies with the stress, increasing from the outer surface towards the centre of the lower portion where the stress is greatest. In the side span adjoining New Street under the hipped ribs of the general market roof adjacent to the fish market, a special form of transverse truss is adopted, the whole being rigidly connected together, so as to avoid trussing the ridge longitudinally.

The central span of the roof, is considered to need no diagonal wind bracing, but the side spans are thoroughly braced diagonally with 3 inch by ⅜ inch bars.

The roofs over the fish market and three-cornered piece of ground adjoining it (previously alluded to), are to be roofed over with principals formed of straight inclined trusses with vertical members intersecting one another to suit the design, and are explained in the diagrams exhibited by the author.

The total quantity of wrought iron to be used in the main roofs and fish market is estimated at 400 tons, and of cast-iron 130 tons. The weight per square of area covered will equal 15 cwt., including gable screens, girders, &c. The weight of cast-iron per square, columns, &c., will equal 5 cwt.

The ironwork has been designed by the author for the architects engaged by the Corporation of Carlisle, Mr. Arthur Cawston, of Queen Anne's Gate, Westminster, and Mr. Joseph Graham, of Fisher Street, Carlisle. Messrs. Hodgson & Co., of Workington, are the general builders. Messrs. Robertson & Co. are the contractors for the ironwork, and all the wrought iron is being prepared at their works at Workington. Mr. H. C. Charlton is the clerk of works at Carlisle; Mr. Robert Masefield, the resident inspector at the ironworks; and Messrs. Corderoy and Selby, of Westminster, are the quantity surveyors.

It is hoped that the architects' desire to economise space and cause a minimum amount of obstruction to traffic by the use of as small a number of columns as was consistent with a suitable design, as well as the avoidance of steps leading to and from the market, will meet with the approbation of the members of the Association of Municipal Engineers and Surveyors who have now done us the honour of visiting the works.

APPENDIX.

The following is a summary of the calculations of the stresses in the roof principals:—

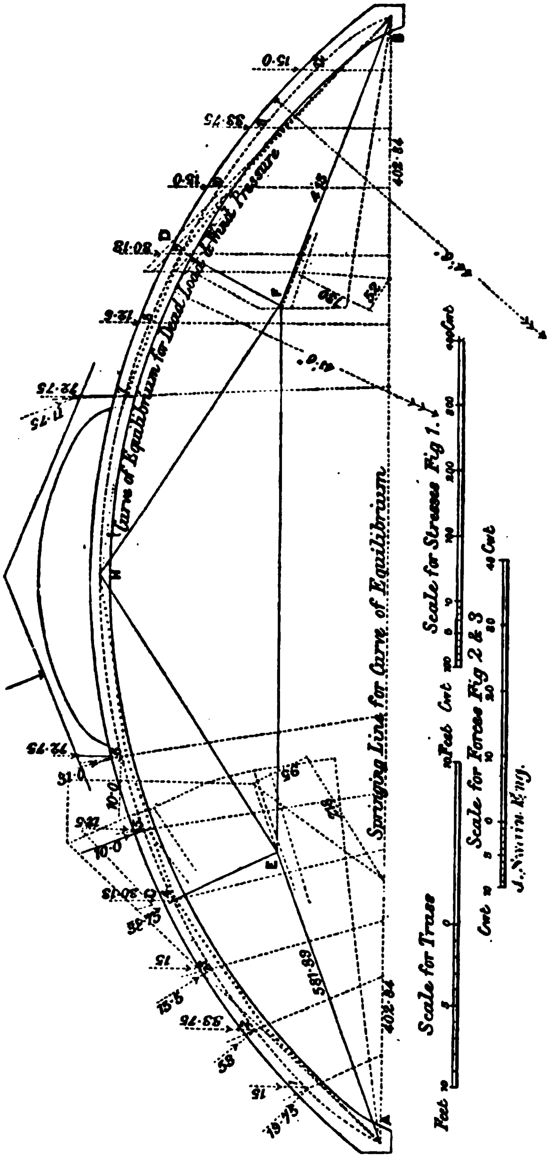
DEAD LOADS (vertical).

Point.	Load in cwts.	Point.
1	15·00	12
2	33·75	11
3	15·00	10
4	30·13	9
5	12·50	8
6	72·75	7

Taking 50 lb. per square foot, wind pressure, blowing horizontally, the following is a summary of the total pressure met:—

Points upon diagram.	Angle of roof. Deg.	Normal pressure. Pounds per sq. ft.	Areas. sq. ft.		Total normal pressure in cwts.
1	48	46·4	47·5		19·75
2	40	41·6	142·5		53·00
3	34	36·4	47·5		15·50
4	27½	30·4	142·5		38·75
5	21	23·6	47·5		10·00
6	14	16·3	47·5 =	6·9	31·00
6	Reaction to ventilator			24·1	
6	Horizontal pressure on louvres				10·00
7	Reaction to ventilator				11·75

FIG. 6.


Curve of Equilibrium for Dead Load & Wind Pressure
Springing Line for Curve of Equilibrium
Scale for Stresses Fig 1.
Scale for Truss
Scale for Forces Fig 2 & 3
J. Swain Eng.
Feet
Cwt
A
B
D
E
F
H
15·0
33·75
16·0
20·18
12·5
12·75
11·75
402·84
581·89
42·75
31·0
10·0
20·18
32·75
15
15·5
33·75
38
15
19·75

NOTE.—The Diagrams are kindly supplied by the Proprietors of 'The Engineer.'

The resultants of the above forces are obtained by Figs. 7 and 8, and are drawn through their respective points in Fig. 6, until they cut the springing line. The reactions of the forces at A—truss being fixed on the weather side and free on the lee side—are 281·89 cwt. vertical and 97·65 cwt. horizontal. The reaction at B—vertical only—is 228·53 cwt.

FIG. 7.

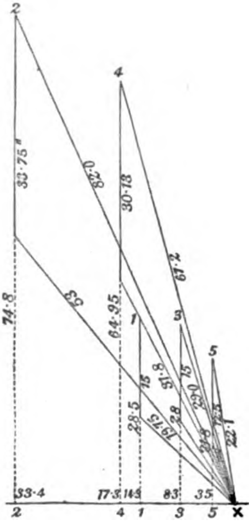
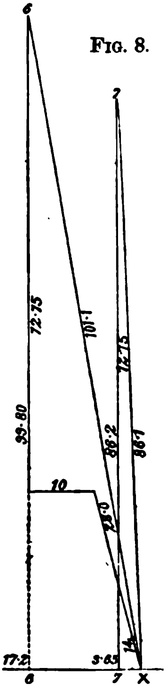


FIG. 8.



The following is a summary of the stresses in the bracing of the principals, which will be understood by reference to the diagrams herewith.

Stress in E F =

$$\left\{228 \cdot 53 \times 34 \cdot 4 - (86 \cdot 2 \times 11 + 12 \cdot 5 \times 13 \cdot 55 + 30 \cdot 12 \times 19 \cdot 8 + 15 \cdot 0 \times 23 \cdot 9 + 33 \cdot 75 \times 27 \cdot 6 + 15 \cdot 0 \times 31 \cdot 1)\right\} \div 10 \cdot 9 = 402 \cdot 84 \text{ cwt.}$$

Stress in A E =

$$\left\{(281 \cdot 89 \times 14 \cdot 6 + 97 \cdot 65 \times 12 \cdot 6) - (31 \cdot 8 \times 13 \cdot 8 + 82 \times 9 \cdot 15 + 29 \times 4 \cdot 6)\right\} \div 6 \cdot 80 = \frac{3953 \cdot 484}{6 \cdot 8} = 581 \cdot 39 \text{ cwt.}$$

Stress in B F =

$$\left\{(228\cdot53 \times 14\cdot6) - (15 \times 4\cdot1 + 33\cdot75 \times 7\cdot8 + 15 \times 11\cdot3)\right\} \div 6\cdot8$$

$$= \frac{2818\cdot288}{6\cdot8} = 414\cdot45 \text{ cwt.}$$

The stresses in C E—E H—H F and F D are obtained graphically by force diagrams on Fig. 6, and the stresses figured on the lines parallel to the various members.

The stresses in the rib are arrived at by drawing a curve of equilibrium for the tabulated loads combined with the stresses already found in the bracing. The polygon is shown in Fig. 1 by the thick dotted line, and the force diagrams by which it is obtained by the vector lines drawn from the springing points.

The greatest stress in the rib occurs in the second division from B, where the curve of equilibrium is furthest removed from the rib.

$$\text{Tension in outer flange} = \frac{529 \times \cdot05}{1\cdot5} = 17\cdot6 \text{ cwt.}$$

$$\text{Compression in inner flange} = \frac{529 \times 1\cdot55}{1\cdot5} = 546\cdot6 \text{ cwt.}$$

Note.—Details of the ironwork for the above roofs will be found in Plates 40 and 41 of 'Iron Roofs' (second edition), published by Messrs. E. & F. N. Spon. A copy of the specification is also added in the description given in this book, by the author.

CARLISLE PUBLIC SLAUGHTER-HOUSES.

By H. U. McKIE, M. Inst. C.E., City Surveyor, Carlisle.

The slaughter-houses were commenced at the end of October 1886, and opened at the beginning of November 1887. The area of the site is over an acre. Frost stopped the works for three months, and a large portion of the walling had to be taken down and rebuilt.

The buildings, as will be seen from the accompanying plan, consist of five separate blocks, viz.:—

I. Slaughter-houses and cooling-rooms for cattle and sheep.

II. Lairage for cattle and sheep.

III. Pig slaughter-house, cooling-room, boiler-house, and tripery.

IV. Piggeries.

V. Office, stores, fodder-house, meter-house, w.c. and urinal.

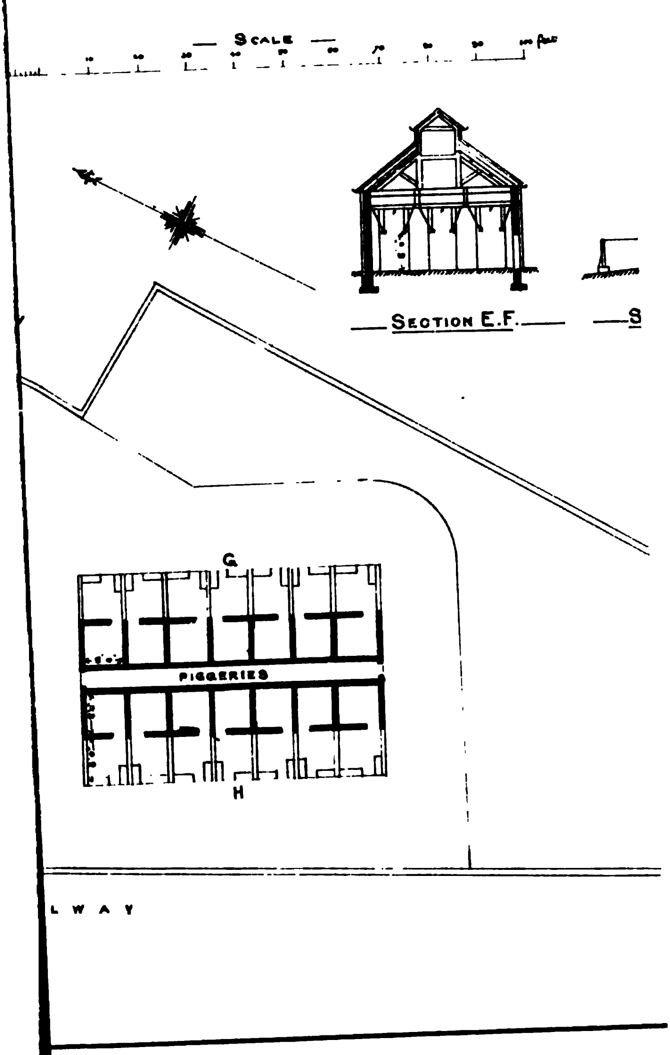
The cost of the work was:—

	£	s.	d.	£	s.	d.
Brickwork and masonry	2782	13	1			
Concrete floors	555	11	4			
Joinery	690	1	7			
Ironwork	489	2	1			
Plumbing	141	15	2			
Painting and glazing	200	7	6			
Slating	131	16	0			
Total for Contract Work				4991	6	9
Drainage, automatic flushing tanks, and ventilation of sewers, done by the Surveyor's staff				170	16	3
Gas and water mains and fittings, laid by the Corporation Gas Committee				310	4	8
Flagging and paving				97	2	1
Clerk of work				68	0	10
Plant and fittings				223	13	6
Road approaches				240	15	1
Total Cost				£6101	19	2

The cost of the buildings, including the machinery, gas and water service, sewers, and all other fittings, was 4*d*. per cubic foot. Concreting the roadways and gravel foundations cost 3*s*. 3*d*. per

RLISLE PUBLIC SLAUGHTER HOUSES.

ERECTED IN 1887



TER HOUSES

H.U. M^c KIE.

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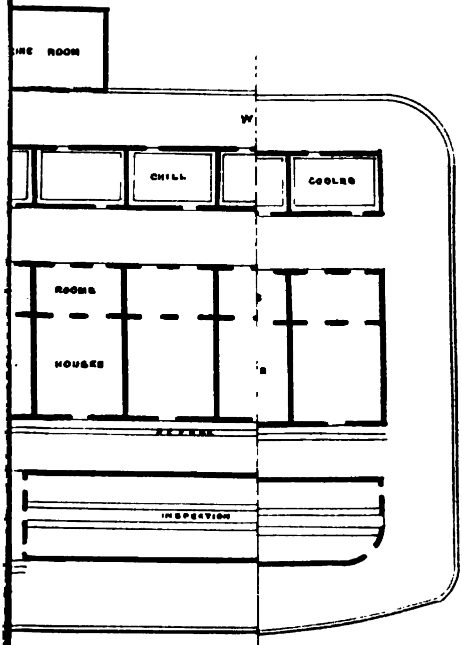


square yard. The boundary wall, 14 feet 6 inches high, is a 14-inch wall, with 9-inch panels and terra-cotta coping, cost 12*s.* 5*d.* per lineal yard. In getting out the cost per cubic foot the height of the buildings was taken from the top of the footings to half-way up the gables.

The pigs have been kept entirely separate from the cattle and sheep, being on the left side of the main entrance roadway. The buildings have been designed so that animals being taken into them never see the slaughtering till they are taken to be slaughtered; the approaches to the different alleys being shut off by large sliding gates, hung on Hatfield's patent pulleys.

With a view of keeping the buildings cool, as much sun has been shut out of them as was possible, considering the aspect they have.

The inside of the slaughter-houses and cooling-rooms are lined, for a height of 6 feet, with white enamelled bricks. The rest of the buildings are of stock bricks, with pressed brick pilasters and arches.

The floors are of concrete, in two layers, the bottom one of 1 of cement to 4 of gravel and sand, and the top layer of 1 of cement to 2 of Dalbeattie granite. In the outside floors the bottom layer is 3½ inches thick, and the top layer 1½ inches thick; in the inside floors the bottom layer is 2 inches thick, and the top layer 1 inch thick. The surface is finished rough to give a good foothold.

The offal is collected for removal by means of tubs, which are taken when full on iron two-wheeled carriages to the crane in the main roadway, and hoisted up and emptied into the tumbler cart, and carted away each day by a contractor, who pays 2*s.* 6*d.* a ton for it. You will notice that the carriages and tubs are so arranged that one man can easily load the tubs and tip them into the tumbler cart.

The following is a short description of each block:—

I. CATTLE AND SHEEP SLAUGHTER-HOUSE BLOCK.

This block consists of seven slaughter-houses, each 18 feet by 18 feet, and seven cooling-rooms, 18 feet by 12 feet each. There is room to keep the carcases of 12 beasts and 64 sheep in each cooling-room, and 12 more beasts and 36 sheep in each slaughter-house. That is to say, that 168 beasts and 700 sheep can be slaughtered in one day, and the carcases left on the premises to cool.

The slaughter-houses are fitted with overhead rails, which run through the slaughter-houses and cooling-rooms, and out under the overhanging roof, which projects 6 feet into the loading alley; the latter is to enable the carcases to be loaded for the market under cover. The beasts are hung from the overhead rails, and the sheep from side rails fixed to the walls, just above the glazed brick-work.

II. Lairage Block.

To the west, on the opposite side of the slaughter-house alley, each of the slaughter-houses has lairage for cattle and sheep. The byres hold four cattle each, and are 15 feet 1 inch by 11 feet 3 inches. The sheep sheds hold 30 sheep each, and are 15 feet 1 inch by 13 feet; they are divided down the centre by an iron railing and a water-trough. The doors to these lairs are so arranged that the animals are obliged to go the way they are wanted to. The total number of animals that can be kept in these lairs is 29 cattle and 210 sheep.

The Corporation have decided to build an additional byre to hold 16 cattle.

III. Pig Slaughter-house Block.

This block consists of a pig slaughter-house, 30 feet 6 inches by 30 feet; a cooling-room, 34 feet 6 inches by 30 feet; a boiler-house, 30 feet by 10 feet; and a tripery, 30 feet by 15 feet.

The slaughter-house and cooling-room are fitted up with three rows of overhead rails, with three scalding tubs at the west end, and three large doors, 7 feet 6 inches wide, at the other end, where the carcases can be loaded for market. These doors are fitted with Attwood's patent rolling shutters. The tubs are heated by steam direct from the boiler; steam is also laid on into the tubs in the tripery. The building is lighted by a glazed portion along the whole length of the centre of the roof, with louvres for ventilation on each side of it. It is also ventilated by means of movable louvres in the north wall; 234 pigs can be hung in the cooling-room, and 102 more in the slaughter-house, making a total of 336, which can be killed in a day and their carcases left to cool.

IV. PIGGERIES.

The piggeries consist of fourteen separate pig-sties, with a raised range and inspection passage down the centre. The feeding-troughs are placed along the front, and the pigs are fed through doors, hung so that the troughs can be either shut in or out of the sties. Each piggery will hold fifteen pigs, making a total of 210 pigs which can be kept in the piggeries.

V. THE OFFICE BLOCK.

This block is situated near the entrance, and consists of a superintendent's office, 15 feet by 13 feet; store-room, 15 feet by 13 feet; fodder-house, 15 feet by 20 feet; meter-house, 8 feet by 8 feet; w. c. and urinal.

Nearly all the butchers in the city have gone into the slaughter-houses, which are paying their working expenses and the interest on the money borrowed for their construction, though they have only been opened six months.

The following are the charges made:—

Killing a beast, 1*s*.
„ calf, 6*d*.
„ sheep and lambs, 2*d*.
„ pig, 6*d*.
„ pig under 56 lb., 3*d*.

Lairage after the first 36 hours—beasts, 3*d*. a day; pigs, sheep, lambs, and calves, 1*d*. a day; half these charges are made if the animals are kept in the paddock outside.

Accompanying this paper is a small scale plan and sections of the slaughter-houses as they are built, and also a small scale plan of the author's original design, which shows the building containing cooling-rooms, and cold dry air rooms artificially cooled. This is what might be required if the whole of the slaughtering for the city and export trade was to be provided for.

POLICE OFFICE AND CELLS, CARLISLE.

BY H. U. MCKIE, M. INST. C.E., CITY SURVEYOR, CARLISLE.

IN 1879 the accommodation at the police office was found inadequate, there being only two small cells on the lower basement floor, 5 feet 4 inches by 8 feet, and three cells on the basement floor, 9 feet by 6 feet. The chief-constable's office was only 15 feet by 6 feet 6 inches; the day-room, 15 feet by 14 feet; committee-room, 24 feet by 16 feet; and on the present site there was also the chief-constable's house, consisting of kitchen, sitting-room, three bedrooms, pantry, and w.c.

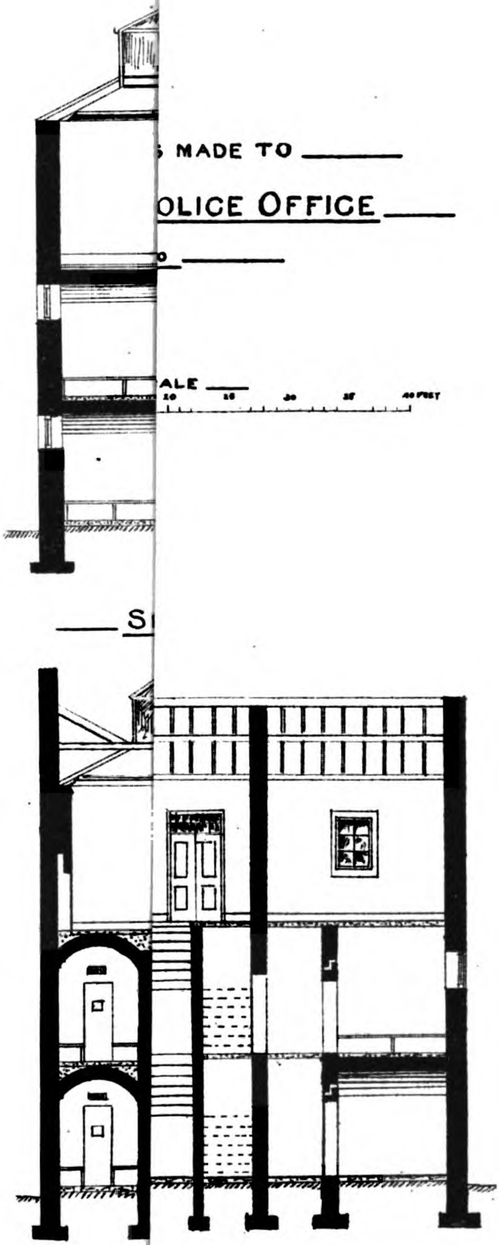
The Watch Committee requested the author to prepare plans giving extra accommodation, doing away with the old chief-constable's house, and building a new one, to the north of the police office, but not communicating with it.

After fully considering the subject and making several sketch plans for the committee, the author recommended the Watch Committee to gut all the interior wall out except the staircase, and entirely remodel the interior of the police office. The result was to get six cells on the lower basement floor, which is the same level as the ground at the outside of the old city wall, and level with the drill ground, nine cells on the basement floor,—in all fifteen more convenient and larger cells than the five old ones.

On the ground floor or level of the west walls and the principal entrance to the police office, the day-room was increased to 22 feet 3 inches by 14 feet 6 inches; the sergeants' office 14 feet 9 inches by 13 feet 3 inches, there being no sergeants' office before; a chief-constable's office 14 feet 9 inches by 13 feet 3 inches; committee-room and library for records of patents, 23 feet 6 inches by 22 feet 3 inches; passage, 6 feet 6 inches wide, in lieu of the old passage, 4 feet 6 inches wide.

The boiler-house for heating apparatus is on the lower basement floor, and all the cells are heated with 4-inch diameter hot-water pipes.

The ventilators are so arranged that the ventilation of all the cells or any one of them can be manipulated from the day-room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without going near the cells, and it can be seen at once how each cell is ventilated from the day-room—ventilating regulator and indicator.

The whole of the building is well ventilated, and each w.c. soil-pipe has a separate ventilator carried above the roof.

The alterations were extensive. In addition to the police office, a new chief-constable's house was erected four stories high, and has front and back entrance, the latter entering the drill ground.

The house contains dining-room, 14 feet 16 inches by 18 feet; drawing-room, 12 feet 3 inches by 14 feet; five good bedrooms; kitchen, 14 feet by 11 feet; bathroom, 2 w.c.'s, lavatory, pantry, scullery, washhouse, storeroom, coal-house, &c.

	£	*s.*	*d.*
The cost of remodelling the police office was ..	1770	0	0
The cost of building the chief-constable's house was	850	0	0
The cost of police office and chief-constable's house being	£2620	0	0

The cost of the alterations at the police office was $5\frac{1}{10}d.$ per cubic foot.

The cost of the chief-constable's house was $3\frac{6}{11}d.$ per cubic foot.

In getting out the cost per cubic foot the height of the building was taken from the top of the footings to half-way up the gable.

The small scale plan and sectional elevation shows the general arrangements. The passage to the basement floor cells is lighted by Hayward's patent floor and stall lights.

Captain the Hon. C. G. Legge, H. M. Inspector of Constabulary, in his annual report to the Home Secretary for 1880, says:

"The police buildings are undergoing extensive alterations; it is intended to convert the head-constable's quarters into six good cells. The improvements were much needed and will facilitate carrying on the duties of police."

In his report the following year, he adds: "The alterations referred to last year in the police buildings have been satisfactorily completed."

Captain Wilson, H. M. Inspector of Prisons, inspected the police cells, and said that they were very good, and that he could safely report favourably on the construction and accommodation of the police cells, west walls.

GULLIES.

By H. U. McKIE, M. Inst. C.E., City Surveyor, Carlisle.

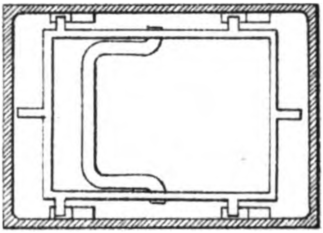
The accompanying plan shows a gulley which, by simply reversing the sludge box, can be left trapped or untrapped.

It will be seen that the sludge box has lugs cast on it which rest on corresponding lugs cast on the gulley; there are two sets of lugs on the latter, and by turning the box it can be made to rest on the higher or lower set, and the gulley left untrapped or trapped at will.

The object in having gulleys of this design, is to overcome the difficulty of having them frozen, as during a frost they can be left untrapped.

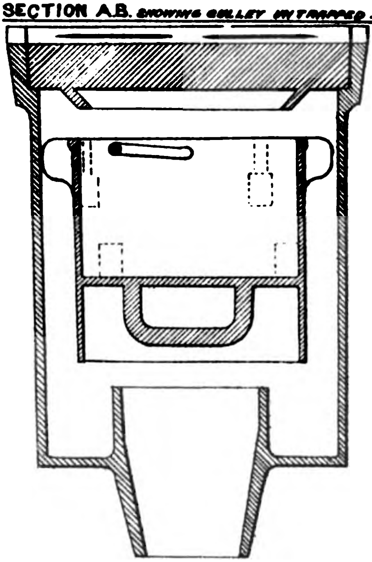
It might also be useful to have gulleys to ventilate sewers in isolated places.

PLAN AT E.F.



Inches

SECTION A.B. SHOWING GULLEY UNTRAPPED



RECORD OF HOUSE AND OTHER JUNCTIONS ON MAIN SEWERS.

By H. U. McKIE, M. Inst. C.E., City Surveyor, Carlisle.

The importance of having a true record of house and other junctions will be patent to all who have been bothered for the want of such a record. The records prevent injury to the sewer, as it need not be cut into, injured, or disturbed by opening, and the private drain connection with the sewer can be made at the least possible cost of labour and with the least interference with the traffic of the streets.

The positions of the junctions have been fixed by taking the distance above or below house-door jambs, window jambs, line of buildings, street corners, and other prominent landmarks, as near as possible to the junction to be recorded.

The following is an abstract from the record-book :—

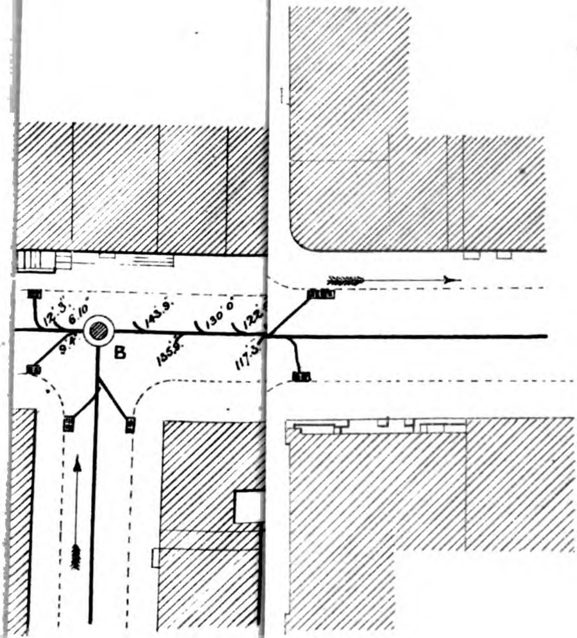
Name of Street.	Distance to Junction from some point near it.		Description.	Chainage.	
			(Right hand with flow of Sewer.)		
	ft.	in.		ft.	in.
From M.H. A to M.H. D 12-inch pipes.	4	0	Below line of Senhouse Street, lined from D. Wilkinson's shop front.	13	9
	0	4	Low side of lower jamb of house door No. 45 ..	32	0
	3	3	,, ,, ,, passage 1st from Senhouse Street.	47	10
	2	0	Low side of lower jamb at passage belonging to shop No. 43 (Regan's).	52	10
	3	10	High side of lower jamb of shop door No. 43 ..	63	0
	2	5	Low side of spout between Regan's shop door and Cockton's shop.	76	3
	0	6	High side of high jamb of Cockton's shop door ..	89	6
	2	0	Low side of lower jamb at passage between Cockton's and Nicholson's (solicitor) office.	104	0
	3	6	Low side of lower jamb of office door belonging to Nicholson, solicitor.	117	3
	4	0	Below line of low side of Catherine Street	135	9
			Up to M.H. B	152	9
	4	6	Below line of high side of Catherine Street ..	9	4
	3	2	Low side of lower jamb of Athenæum door	35	8
	3	6	Low side of spout for Athenæum	43	0
	9	9	High side of high jamb of Athenæum door	53	6
	1	3	Below line of Post Office gable end in Well Lane	77	0
			Up to M.H. C	81	6

Name of Street.	Distance to Junction from some point near it.		Description.	Chainage.	
	ft.	in.		ft.	in.
From M.H. A to M.H. D 12-inch pipes.	3	6	High side of high jamb of No. 31	11	9
	3	6	Low side of wooden spout between No. 31 and house above.	16	9
	0	9	Below line of low side of Queen Street	53	2
			Up to M.H. D	67	0
			(Left hand with flow of Sewer.)		
	6	6	Below line of Senhouse Street, lined from Wilkinson's shop front.	11	3
	5	2	High side of high jamb of 1st door above Smith's shop door.	28	8
	4	10	High side of high jamb of 2nd door above Smith's shop door.	49	6
	3	3	Low side of spout, 1st from Senhouse Street ..	57	5
	1	7	High side of lower jamb of yard door of house with six steps in front, or 7 feet high side of gable end of same house.	68	6
	11	4	Low side of gable end, high side of building ground.	81	9
	2	4	Low side of spout near corner of house, high side of building ground.	91	6
	7	0	Low side of lower jamb of door of No. 54	98	4
	1	10	High side of high jamb of door No. 52	115	0
	3	4	Low side of spout between Nos. 52 and 50	122	9
	8	0	Low side of lower jamb of house No. 50	130	0
	1	8	Low side of high jamb of No. 48	143	9
			Up to M.H. B	152	9
	7	0	Below line of high side of Catherine Street, line from Athenæum.	6	10
	1	6	Below line of high side of Catherine Street	12	3
	2	0	Below line of lower jamb of No. 44	22	0
	5	3	Low side of lower jamb of No. 42	40	4
	4	0	Low side of spout on Post Office	45	0
	3	9	Below line of Post Office gable end in Well Lane	74	5
			Up to M.H. C	81	6
	5	8	Low side of spout, 1st from Well Lane	13	7
	3	6	High side of high jamb of 1st house from Well Lane.	27	0
	5	2	Low side of wooden spout in corner of house No. 34.	34	6
	8	4	Low side of lower jamb of passage between Nos. 32 and 30.	60	8
			Up to M.H. D	67	0

The term used, "high side" or "low side" of jamb, &c., means that the junction is so many feet and inches below or above the object named. The "high side" means up the inclination of the sewer, and the "low side" means down the inclination of the sewer.

THE POSITION O

SEWERS



The measurements where practicable are squared off from the line of buildings, &c., so as to be able to fix their position to a nicety. The right or left hand with flow of sewer, means that the junctions are on the right- or left-hand side of the sewer looking down the flow of sewer.

The chainage of the junctions always commences from the centre of man-hole cover of the nearest man-hole down the flow of sewer and chained up to the next man-hole up the flow of sewer; thus the figures on the plan denote that the junctions are so many feet and inches above the nearest man-hole at the lower side of the sewer; and it is only necessary, when the position of a junction is required to be found, to refer to the plan to find which is the most suitable junction for the connection of the property to be drained, and then turning to the record of junctions, opposite the length given on the plan will be found a description as to the position of the junction with regard to door jambs or other landmarks, or, if a junction is wanted for any connection, it can easily be found from the record book alone by the description given, as any one having the book on the ground would be able to determine the exact position of each individual and separate junction on every line of sewer.

LAZONBY FLAGS, NEAR PENRITH, CUMBERLAND.

By H. U. McKIE, M. Inst. C.E., City Surveyor,
Carlisle.

Some Particulars and Tests of the Lazonby Flags.

These flags have been used in Carlisle from time immemorial; they are very durable, and give good foothold when wet or dry. Some of these flags in the footways in Carlisle streets have been in use over 60 years, having in that time been taken up, redressed, and relaid. Good selected smooth self-faced Lazonby flags of first quality, when laid on a good foundation on a one-inch bed of ground mortar, will wear evenly down from 3 inches to 1¾ inch in thickness or less.

The second quality flags do not wear evenly, nor are they durable or desirable for heavy traffic in public street footways.

The author has, however, seen no flags which, in his opinion, are equal to good self-faced first quality Lazonby flags.

Geological Formation of Lazonby Flag Rock.

Permian Rocks between Penrith and Carlisle.

Permian	St. Bee's sandstone.
	Red shales, with gypsum.
	Magnesia limestone and plant beds.
	Penrith sandstone.

The Penrith sandstone is an immense mass of orange, red, and yellowish sandstone, forming the lowest member of the Permian group in the district around Penrith.

The Lazonby stone and flags constitute part of the Penrith sandstone. About Appleby and Brough the lowest beds of this rock pass into a breccia, generally known in the district as brockram.

There are two marked characteristics by which the Penrith sandstone is distinguished, viz. the large scale upon which the cross-stratification or false bedding is developed, and the angular or sub-angular shape of the quartz grains, which mainly enter into its composition; so excessive is the amount of false bedding, that it is almost impossible to obtain an accurate idea of the amount of the true inclination of the rock.

The Penrith sandstone, besides being the principal source from which all the local building stone is obtained, yields excellent flags. These flaggy beds are largely developed on Lazonby Fell, hence they are called Lazonby flags. The lamination of these flags is not parallel to the general plane of the stratification, but is the result of false bedding. Hence the flags do not occur in regular layers, but in detached patches; consequently a considerable area on Lazonby Fell is covered with rubbish from quarries, where flags have either been got or tried for.

Angular or only slightly rolled small grains of quartz covered with a thin layer of hæmatite form the main constituent of this sandstone. In the interstices between the quartz grains are white soft pasty-looking grains, mainly fragments of felspar more or less decomposed. Both the hæmatite and the felspar act as the cementing material. Mica is very seldom present.

There are some white beds in the Lazonby flags, but not to a great extent. There is no film of hæmatite round the grains of quartz in the white flags. The matrix is still of felspar, and the greater hardness seems to be due to the filtration through and crystallisation of the secondary quartz round the original grains; hence the bright glistening appearance.

Analysis of the white beds of Lazonby flags is as follows: Silicic acid, SiO_2—95·12; aluminium oxide, Al_2O_3 2·51; ferrous oxide, FeO—1·19; calcium oxide, CaO—0·18; water, 0·85: Total, 99·85.

A considerable portion of the Penrith sandstone, especially the upper beds of the series, exists in a soft, half-consolidated state, and is utterly worthless for building purposes.

The lower and harder beds contain a varying quantity of double six-sided pyramids of quartz. The sides are usually well defined and bright. To these bright crystals is due the sparkling appearance which the rock generally presents.

The crystallized forms seem to be due to the deposition of secondary quartz around rounded grains as nuclei. Since the crystallisation took place the grains have been partly water-worn prior to final deposition in their present position and before the coating of hæmatite was formed around them, because the hæmatite covers both the rubbed and unrubbed faces of the quartz crystals alike.

The Penrith sandstone rock is coarser-grained, and in this respect is somewhat like a millstone grit, whereas the St. Bee's rock is finely grained and very evenly bedded.

The author noticed in the Nith and the Scar valleys, near Thornhill, a bed of sandstone very similar to the Lazonby beds. This is the only other bed that the author has seen like the one at Lazonby.

COMPARATIVE TESTS OF LAZONBY AND OTHER FLAGS.

The different descriptions of the tests are as follows, viz.:—

I. Comparing their absorbent powers.
II. Their wear when rubbed on a plain surface.
III. Their microscopical appearance.
IV. Their wear when subjected to the action of a drill.
V. Their adhesive strength.

I. The absorbent powers of the different Stones.

All the stones were carefully dried, weighed, and then immersed in water for 27 hours, and then re-weighed, which gave the following results.

TABULATED STATEMENT OF WEIGHT OF A CUBE FOOT OF LAZONBY STONE.

		Name of Stone.	Weight per c. ft. when dry.	Weight per c. ft. when wet.	Absorbent powers per c. ft.
			lb. oz.	lb. oz.	lb. oz.
Lazonby.	No. 1.	Lazonby Old Quarry (white)	153 15	156 10	2 11
	2.	Lazonby New Quarry (red) ..	159 6	161 11	2 5
	3.	Lazonby New Quarry (white)	151 13	154 13	2 4
	4.	Bleasfell Quarry	147 4	150 13	3 8
	5.	Nepstone	150 12	152 10	1 14
	6.	Haltwhistle Quarry	152 1	155 8	3 7
	7.	Caithness	163 4	163 4	0 00

II. Wear of Stones by Friction.

All the stones were now reduced to one thickness, 2 inches, and placed on a revolving circular metal float for two hours, being all the time supplied with sand and water to assist the grinding. During the two hours they travelled over a space of 20 miles.

TABULATED STATEMENT OF WEAR OF STONE BY FRICTION.

	Name of Stone.	Result of test in hundredths of an inch.
Lazonby.	No. 1. Lazonby Old Quarry (white)	No perceptible wear
	2. Lazonby New Quarry (red)	$\frac{2}{100}$
	3. Lazonby New Quarry (white)	$\frac{2}{100}$
	4. Bleasfell Quarry	$\frac{3}{100}$
	5. Nepstone	No perceptible wear
	6. Haltwhistle	$\frac{2}{100}$
	7. Caithness	$\frac{5}{100}$

III. *Tabulated Statement of Microscopical Examination of Stone.*

	Name of Stone.	Description and Remarks.
Lazonby.	No. 1. Lazonby Old Quarry (white)	Is a round grit, and the grains very adhesive, having in it a number of small grains pure white and soft like paste.
	2. Lazonby New Quarry (red) ..	Same as above.
	3. Lazonby New Quarry (white)	Same as above.
	4. Bleasfell Quarry (red)	Is a coarse grit, the grains unadhesive and full of vacuities.
	5. Nepstone	Same as Lazonby red, or a little more adhesive.
	6. Haltwhistle	Very close grained and very adhesive.
	7. Caithness	Same as Haltwhistle, but finer grain and more adhesive.

IV. *Test by Drilling the Stone.*

All the stones were drilled for the space of one minute with a ¾-inch drill and loaded on the top with 100 lbs. The drill was set to an angle of 105 degrees, and performed 32 revolutions per minute.

TABULATED STATEMENT OF DRILL TEST.

	Name of Stone.	Result of Test.
Lazonby	No. 1. Lazonby Old Quarry (white)	Depth drilled $\frac{17}{100}$ of an inch, taking Lazonby as standard or 100 per cent.
	2. Lazonby New Quarry (red) ..	Same as above.
	3. Lazonby New Quarry (white)	Same as above.
	4. Bleasfell Quarry (red)	Depth drilled $\frac{32}{100}$ of an inch will be 53 per cent.
	5. Nepstone	„ „ $\frac{17}{100}$ „ 100 „
	6. Haltwhistle	„ „ $\frac{23}{100}$ „ 73 „
	7. Caithness	„ „ $\frac{36}{100}$ „ 47 „

V. Adhesive Strength of Stone.

All the stones were again tested as to their adhesive strength as per annexed diagram. The square corner of the flag projecting over space 4 inches measured on the sides of the square and the weight applied 1 inch from the corner measured on the intersection of the right-angle.

TABULATED STATEMENT OF ADHESIVE STRENGTH OF STONE.

	Name of Stone.	Result of Test.
Lazonby.	No. 1. Lazonby Old Quarry (white) ..	Weight sustained in lbs. 748, being 14½ per cent. of strength of Caithness.
	2. Lazonby New Quarry (red) ..	No test, say same or a little less.
	3. Lazonby New Quarry (white)	„ „ „
	4. Bleasfell Quarry (red)	Weight sustained in lbs. 298, being 6 per cent. of strength of Caithness.
	5. Nepstone	Weight sustained in lbs. 760, being 15 per cent. of strength of Caithness.
	6. Haltwhistle	Weight sustained in lbs. 1642, being 32 per cent. of strength of Caithness.
	7. Caithness	Weight sustained in lbs. 5100, being 100 per cent. as standard.

DIGEST OF THE FOREGOING TESTS.

I. That Bleasfell is 56 times more absorbent than Caithness.
Lazonby, 43 to 36 „ „ „ „ „
Nepstone, 30 „ „ „ „ „

II. When subjected to the metal float test, we have Lazonby and Nepstone far the best, not having worn any, Bleasfell only $\frac{2}{100}$ of an inch, and Caithness $\frac{5}{100}$ of an inch.

IV. When drilled we have Lazonby and Nepstone the hardest, and if we call these the standard or 100 per cent. we have

Haltwhistle	77	„ „ „
Bleasfell	37	„ „ „
Caithness	47	„ „ „

V. When tested as to strength by applying pressure as per diagram,

Calling Caithness the standard or 100 per cent.,

Haltwhistle	32	„
Nepstone	15	„
Lazonby	14½	„
Bleasfell	6	„

The substance of the foregoing tests has been extracted from an unpublished report to the author's council on Lazonby flags which he made 30 years ago.

MUNICIPAL WORK IN CARLISLE DURING THE LAST ELEVEN YEARS.

By H. U. McKie, M. Inst. C.E., City Surveyor, Carlisle.

The area of the city until last year was 1570 acres, but an Omnibus Act was obtained in 1887 to extend the boundary, &c., making the present area 2029 acres.

The population at last census was 35,866; it is now estimated at upwards of 40,000.

The rateable value of the city in 1877 was 107,151*l.*; it is now 153,332*l.*

Most of the streets in the city were paved with cobbles until eleven years ago. Many of the private streets were not paved at all. Since then the following works of street re-formation have been carried out.

62 public streets have been re-formed and re-paved (including the main streets of the city).

102 private streets have been formed and paved.

The total length of streets re-formed is nearly 16 miles.

150,740 square yards new pavement have been put down, made up as follows:—

43,625	square yards	4 in. whinstone cubes.
12,460	„ „	3 in. by 6 in. to 4½ in. by 6 in. whinstone setts.
2,032	„ „	Whinstone random blocks.
53,455	„ „	„ chips.
4,905	„ „	3 in. by 6 in. to 4 in. by 5 in. granite setts.
375	„ „	4 in. „ cubes.
636	„ „	Granite random blocks.
33,252	„ „	cobble or boulder pavement.
150,740	Total Square Yards.	

The bulk of the whinstone paving stones came from Greenhead Quarries, Northumberland, from the bed called the Whinstone Sill, and some from Brampton, near Carlisle, from a trap dyke. The granite came from Dalbeattie, and from the Threlkeld (syenite) Quarries. In addition to the public and private street formation, extensive works of re-making and metalling have been carried out on the macadamised roads.

In footways, 42,047 square yards new 3-inch Lazonby flagging have been laid, and 28,153 lineal yards new 12-inch by 7-inch edging, and 21,355 lineal yards new 10-inch by 5-inch channelling; 32,062 square yards flagging, 10,961 lineal yards edging, and 13,967 lineal yards channelling have been re-dressed and relaid—making the total flagging executed 74,109 square yards; edging, 39,114 lineal yards; and channelling, 35,322 lineal yards.

Besides the usual sewer repairs, 56 new sewers have been put in, and many improvements made to storm water outlets, and flushing arrangements of the existing sewers. The ventilation of the sewers has been assisted by removing the close lamp-hole and manhole tops, which have been superseded by ventilating covers, and twenty-eight of the tall chimneys in the city connected with the main sewers, to assist in their ventilation. Important works in town improvement have been carried out. Principally owing to extensive railway alterations, it became necessary to obtain an Act, and by arbitration and otherwise acquire valuable property, in order to build a viaduct to communicate with the west of the city; but in the same Act power was obtained to improve other parts of the city. Old rookeries in Annetwell Street and Irish Gate Brow also were purchased, knocked down, and the street widened and opened out, and a dangerous hollow between this street and the Caldew bridge filled up. The old property in White Hart Lane running parallel with Bank Street was purchased and demolished, and Bank Street widened from a flagged footway from 11 feet to 17 feet 6 inches wide, to a 50-feet street, and now one of the principal streets in the city.

Property in Fisher Street and Scotch Street was acquired, where a new market is at present being constructed.

Upwards of 150,000*l.* has been expended upon purchase of property, parliamentary and law expenses, new works, repairs to property, &c., but over three-quarters of this amount is covered by the railway companies' contribution, sales of property, and value of property held, &c.

The Corporation own some 320 acres of grazing land adjacent to the city, and a quantity of house, shop, and other property at which considerable work has been done in improving the same.

Amongst the miscellaneous works carried out are the following:—

New public slaughter houses.
Butter and egg market extension.
River protection embankments, and weiring Corporation lands.
Town Hall heating, ventilating, and alteration.
Police Office extension, and new house for chief-constable.
Royal show (Corporation work).
New mortuary.
New offices for town clerk.
New sewage screening chamber.
New bridge at Holme Head.
Laying out Court-house shrubberies.
New fire-engine station.
Alterations at house of recovery.
Laying out West Walls Orchard and Shubbery, Caldewgate, planting avenues of trees in the streets, and in the Sauceries, &c.

Since 1877, the sum of 34,535*l*. has been borrowed for street re-formation works, 6240*l*. for public slaughter-houses, 10,000*l*. for purchase of land, 13,700*l*. for purchase of property in Market Place and under the Town Hall, and 30,000*l*. for the new market now in progress.

The total rates in Carlisle, including poor-rate, school-board rate, &c., amounted last year to 4*s*. 2*d*. in the £. The general district rate, which stood for some years at 3*s*. in the £, is now 2*s*. 1*d*. in the £.

This paper only includes municipal work in the author's department. In addition to that there is the extensive work carried out by the Gas and Water Committees, under their manager and engineer, Mr. Hepworth, during the same period.

THE CARLISLE PUBLIC BATHS.

By J. HEPWORTH, Assoc. M. Inst. C.E., Engineer of the Carlisle Corporation Gas and Water Works.

At the request of the President of this Association, the author has gladly undertaken to contribute a short description of the baths recently erected by the Corporation of Carlisle.

These baths were erected in 1883–4 on a corner site—bounded on two sides by James Street and Wood Street, Victoria Viaduct—previously unoccupied and belonging to the Corporation.

The frontages in James Street and Wood Street are 100 feet and 125 feet respectively, and the total area about 1378 square yards.

The building was intended to be simple and unpretentious in character, and is designed in the domestic style of architecture, carried out in red brick, relieved with red-stone dressings and terra-cotta panels, all of local production.

The basement has been fully utilised, and in addition to the space occupied by the swimming baths, hereafter referred to, ample space has been allotted to a boiler-house, workshops, laundry, and other purposes. In the basement perfect access is obtained to the whole of the exterior sides of the three swimming baths, and to the whole of the water inlet and outlet pipes, to every bath, and to every drain throughout the building. The subways or basement floors are formed of cement concrete.

The ground floor is approached by a few steps from the principal entrance, James Street. To the left of this entrance, the office and residence of the superintendent are situated, and from the window of this office tickets and towels are supplied to bathers before admission to the entrance hall.

The entrance hall forms an important feature of the building. This hall is 20 feet long by 11 feet 6 inches broad, and 16 feet in height, and from it the entrances to all the different sections of the baths radiate. The floor is laid with decorated tiles; round the walls of the hall is carried a panelled and moulded dado of pitch pine; the ceiling cornice, doors, and all the woodwork are also of pitch pine. The upper panels of the vestibule door are glazed in leaded panes and bear the two coats-of-arms of the city of Carlisle, and the upper panels of the other doors leading from the entrance hall are glazed with obscured glass, with the names of each bath cut thereon.

A slab of marble inserted in one of the walls of the entrance hall records the date of erection, the names of the mayor, the members of the Baths Committee, and of the engineer and architect; also the source of the funds out of which the baths were erected.

The baths have been divided into four sections, three of which are completed, viz.:—

Section 1. Gentlemen's first class bath.
„ 2. „ second class „
„ 3. Ladies' first and second class „

The fourth section has been reserved for a Turkish bath which has not yet been constructed. The separate entrance to each section is indicated on the respective doors within the entrance hall.

The whole of the slipper baths are of porcelain, and the swimming baths are constructed of cement concrete.

SECTION I.

In section 1 (gentlemen's first class), situated in the north wing, the entrance corridor divides the slipper baths from the swimming bath. There are four slipper baths—supplied with hot and cold water, with shower attached. Lavatories are fixed in each apartment, and the fittings throughout are of the most modern and complete character.

There are also vapour and spray baths.

The swimming bath in this section is approached from the opposite side of the corridor, and is 60 feet by 30 feet, by 3 feet 6 inches deep to the water line at one end, falling to 6 feet 6 inches at the other. The bath is constructed of cement concrete, the side walls being 2 feet in thickness, and the floor 12 inches in depth. The bottom is paved with white glazed bricks, with three parallel lines of brown glazed bricks along the entire length for the guidance of divers. The sides are tiled with white glazed tiles bordered at the top with tiles of a pale blue pattern. Steps of masonry lead down into the swimming bath at each end. Handrails are fixed round the sides of the bath, and overflows (also used as spittoons) are fixed at convenient distances on the water line.

The water is run into this bath by a 4-inch main, and also by a spray pipe at the shallow end of the bath. The water in the bath is heated by a supply of steam introduced at the deep end of the bath, and the water is discharged at the outlet into a 12-inch diameter pipe, leading to the public sewer. The footways round the bath are laid in coloured tiles, with freestone coping.

There are seventeen dressing-boxes arranged round the footway, and the necessary toilet arrangements have been provided throughout.

The dimensions of this apartment are 72 feet long by 39 feet broad, and the walls rise to a height of 14 feet, being worked in panels.

The dado, mouldings, and pilasters are in red brick, and the panels in buff, relieved by a cornice of terra-cotta bricks.

Running along the greater length of this wing is a lantern light in the roof of this building, which serves the double purpose of giving light and ventilation, and is so constructed as to effectually fulfil its purpose. The roof is constructed of light ironwork of an ornamental character, and is painted in plain colours.

As adjuncts to the swimming bath there are, a foot-bath, with shower bath attached, a lavatory, urinal, diving-stage, and a drinking-fountain of Doulton ware.

SECTION II.

In section 2 (gentlemen's second class), situated in the south wing, 75 feet long by 57 feet broad, there are seven slipper baths, also a vapour and a spray bath. The swimming bath is 65 feet by 30 feet, and the depth of water is the same as in the first class, and as the bath is constructed, lighted, and ventilated in the same manner, no further reference to it is necessary. In this section 28 dressing-boxes have been provided on the north and south sides of the bath. Above the dressing-boxes, balconies with balustrade and seats are provided for the use of spectators on the occasion of a swimming entertainment or competition. The balconies are approached by a stairway leading from the footway, and a foot-bath, shower-bath, fountain, and the necessary adjuncts have been provided as in Section I.

SECTION III.

Section 3 includes the ladies' baths, subdivided into first class and second class. Within the entrance to this section a ladies' waiting-room has been provided, and a corridor leads to the various baths. There are 4 slipper baths, 1 Roman, 1 vapour, 1 spray, and 3 shower baths. A swimming bath, 29 feet by 16 feet, with a depth of water from 3 to 5 feet, 7 dressing-boxes, a foot-bath, and the usual adjuncts, furnishings, and toilet arrangements complete this section.

SECTION IV.

Section 4 is reserved for a Turkish bath if required.

LIGHTING.

The swimming baths and most of the slipper baths are lighted from the various roofs, the remainder from windows in the front of the building. The arrangements for lighting the swimming baths in the evening are by gaseliers of a simple design, made of wrought iron, painted and relieved, and suspended from the roof immediately above the several baths.

HEATING.

The arrangements for heating the building are as complete as possible in every respect.

Hot-water pipes are laid throughout the whole building, those in the swimming and slipper baths being of three inches diameter, and laid through the dressing-boxes; while the entrance hall is heated by a coil of pipes within an ornamental cast-iron case.

VENTILATION.

Ventilators of the Tobin principle have been fixed in the several swimming apartments, and these, with movable openings in the lantern lights, constitute the provision for ventilation.

WATER SUPPLY.

An abundant supply of pure water is obtained from the public mains, from which a 4-inch main has been laid into the building; the water used is measured through a 4-inch water-meter, but is now provided free of charge by the Urban Sanitary Authority.

STEAM BOILERS.

Two Cornish boilers, 16 feet 6 inches long by 5 feet, and a water superheater, fixed in the basement story, have been found necessary for heating the water supplied to the slipper baths, and for providing the requisite steam supplied to the swimming baths, vapour baths, and laundry. The swimming baths are kept at a tepid temperature throughout the year.

A chimney 100 feet high stands in the rear of the boilers.

LAUNDRY.

The laundry is supplied with Bradford's apparatus, including washing boiler, washing troughs, washing machine, wringer, rinser, soap boiler, clothes bins, hydro-extractor, and drying-closet, fitted with six sets of travelling horses running on castors. Steam has been utilised for all laundry purposes, and a small engine of two horse-power drives all the machinery. There are entrances to the laundry and boiler-house from Wood Street.

COST OF BATHS.

The contracts were undertaken by local firms, who carried out the work with the greatest satisfaction.

The entire cost of the building, baths, and furnishings was 7000*l.*, and was provided from the profits of the Gas Works, specially appropriated for the purpose from the city fund, and the engineer of the Gas and Water Works was employed as the engineer and architect for the baths, and was ably assisted by Mr. H. Higginson, architect, Carlisle, then a member of his staff.

The baths were erected to meet a pressing want in the city, and for this purpose the tariff of charges was fixed at a low rate. That this want has been met is abundantly evident in the appreciation and support which is regularly accorded to the baths by all classes of the community.

DISCUSSION.

Mr. **Escott**: With reference to the market, there is one question I should like to ask, and that is with regard to the spandrel girders. I do not see how the engineer is able to dispense with the bracket or seat for the girder at the top of the column. I should like Mr. Walmisley to tell us how he gets strength with such a small seat for the girder.

Mr. **Pritchard**: I am sure that, taking the papers throughout, they have been most interesting and instructive. I scarcely feel any disposition to criticise them; at any rate, I cannot criticise them adversely. Taking them in rotation, I think Mr. Walmisley has given us a fair earnest of what he can do, and what he is celebrated for doing—that is, a thorough theoretical and practical knowledge of the construction of iron roofs. I do not know any gentleman upon whose figures and calculations I should feel disposed to place greater reliance; and I only hope we may have the full calculations, which have been produced, printed in the 'Proceedings' of the Association. The point raised by Mr. Escott is, on the face of it, an important one; but I am sure Mr. Walmisley will be able to give us a good reason for having dispensed with the bracket. I was struck with the convenience of both the baths and slaughter-houses. I have seen and inspected many public buildings of the kind, and it struck me that Mr. McKie had just arrived at the happy position of having enough, and nothing to spare. By his mechanical arrangements he has perhaps reduced the area somewhat as compared with other slaughter-houses I have seen, but he has overcome that difficulty by the mechanical contrivances for the killing and dressing of the cattle. Without setting myself up as an authority on the actual size, I think he has given all that is necessary. As regards general arrangement, ventilation, mechanical arrangement, and work of construction, it would appear practically faultless. The method of enamelled brickwork is a strong point in favour of such a building. It is totally impossible to maintain a proper system of sanitation in such a building unless you have a material forming its walls which you can cleanse simply by throwing water upon them. The adoption of glazed brick is one of the strongest points in recommending the slaughter-house. The drainage appears to be perfect. The flushing, which is automatic in rainfall or in dry weather, not only carries away any filth from the place itself, but it also assists in flushing a main sewer. Judging from a sniff which I took at the manhole, there does not appear much necessity for that. It is quite a pleasure to see the clever way in which the sewers are ventilated. Whether disinfectants are used or not, I am not prepared to say; but if no disinfectants are added to the sewage, it says a great deal for the system of drainage in Carlisle. I should have liked to have had some information from Mr. McKie as to the disposal of the sewage of Carlisle. I believe the sewers and house-drains, both as regards the inclination of the sewers, and the ventilation of the house-drains (carried out, I believe, chiefly under Mr. McKie's direct supervision) are, as far as I can see, perfect; and I am sorry to say that few cities at the present time are in such a happy state as regards their sewers, and methods of ventilation.

Mr. STRACHAN: I have been much interested in what Mr. Walmisley has said about the market roof, and if he will be kind enough to tell me by what train he intends to go to London, I will make his life unhappy. I would like to utter a word of warning with reference to the concrete floors you are going to put in the new market. The area of the floor is going to be over an acre; practically the concrete would be all in one piece; and unless special precautions are taken, it will soon show cracks. If you lay concrete down in bays above ten feet square, the probability is that they will crack across; whereas if you lay it down in squares of three or four feet, the result will be, that while the cracks are there, they will come at the joinings so regularly that the floor will present the appearance of being perfect in surface. That is one of the little things worth taking notice of, and when we come back to see the market, when it is finished, we will be happy to see no cracks in the floor. I would like to call attention to some of the results of the experiments on paving stones made by Mr. McKie, who, before I was born, was a skilled and distinguished engineer. When the tables of results are placed alongside each other, some striking discrepancies are observable. The first experiment was made to show the porosity of the stone. One would suppose that the stone that was most porous was the one which would least stand the test of friction. The Caithness stone was practically impervious to water, and it also bore the highest strain transversely, showing that it is the most closely packed together. There is, however, this curious fact, that while the red stone in

Table I. took in 3½ lb. of water, the Caithness stone took none; yet, taking the test of friction, that stone was two and a half times better than Caithness. I also notice that the stones which have the same ratio for friction on the surface present a very different ratio indeed for the drilling, and one does not understand why they should do so. After two hours' rubbing, during which it travelled twenty miles, the Lazonby Old Quarry white stone did not show any perceptible wear, yet when the drilling machine was applied, after one minute's drilling, the drill went to a depth of $\frac{17}{100}$ths of an inch. The Bleasfell Quarry stone, which under the friction test was worn by $\frac{2}{100}$ths of an inch, under the drilling test showed $\frac{32}{100}$ths of an inch. Then take the case of the Caithness stone, which absorbed no water, it was drilled in the same time $\frac{36}{100}$ths of an inch, or more than twice the Lazonby Old Quarry stone. Then taking the test for the adhesive strength, one finds that the Caithness stone sustains a weight of 5100 lbs. and the Bleasfell stone 298 lbs. One sees that the Caithness stone stood worst the test of drilling, and would like an explanation of these results. It would appear as if closeness of grain had little to do with strength or durability. The probability is, that the lesson to be learned is that individual experiments in this way are not of scientific value, and that the great test is the test of the street in all kinds of weather, and with all kinds of traffic.

Mr. LAWS: It is common experience that the Caithness flags which we get now will not stand many winters' wear; they begin to split up and shell off. I do not quite understand that there is absolutely no absorption of water by the Caithness stone; but perhaps there may be a difference in this respect according to the character of the specimen. Although the dark Caithness stones wear longest, they are the most dangerous stone; and as far as possible in Newcastle, I am discarding them in favour of Lazonby stone, which, although it does not last so long, is safer for streets like those of Newcastle, where there are heavy gradients. There are, besides, only three or four days in the year when the Lazonby stones are not pleasant to walk upon, whereas the Caithness stones are often slippery in summer, and we have had to pay compensation to persons who have been injured by slipping upon the Caithness flags. With regard to Mr. Walmisley's paper on the market roof, I do not see how he allows for the changes of strains produced by the alterations in temperature. I have not had occasion to use that particular form of rib, and I cannot remember a rib with that particular form of trussing in any of the stations or large roofs with which I am acquainted. It appears to me that that form must result in some perplexing cross strains. In my opinion, with the alterations of temperature there must occasionally be pressure outwards. I would like Mr. Walmisley to say if he has considered that point. With the permission of this meeting, I should just like to say a few words with regard to the concrete. I must say I have often been surprised how it is that, with the same proportion of cement, in one case we get watertight concrete, and in another case we get concrete which is perfectly pervious. You all know that there has been some difficulty with regard to the concrete in Aberdeen Harbour, and it has there been found that everything depends on the relative proportions of sand to cement. It is possible to make the concrete perfectly impervious, and it is possible, by changing the proportions of sand, to make it quite porous.

Mr. SPENCER: Upon whatever other points a little difference of opinion may exist, or upon whatever other points information may be wanting, we are unanimous upon this, that the whole of the papers are most useful and valuable to us generally. With regard to the roof of the market, I would like to know what effect the variations of temperature will have upon the watertightness of the slated part of the roof. I can bear testimony to the excellence of the public baths, although I do not know that, from the brief inspection we have had, it is possible to go so thoroughly into the details as to afford any ground for criticism. The Baths having been constructed of concrete, it would be interesting to hear if any leakage has been observed. The public slaughter-house I regard as a boon to the town. I should like to say a word with reference to compelling butchers to use the public slaughter-houses. All sanitary authorities who do not possess the powers in private Acts should take the earliest opportunity of obtaining powers to make the use of the public slaughter-houses compulsory; because I am afraid that many authorities burden the ratepayers by putting up slaughter-houses at great expense, and then fail to induce those to use them who ought to do so. I must congratulate the authorities of the city upon the very excellent condition in which we, as experts and critics, find it to-day, and I also wish to say how pleased we are to have had this meeting with our valued friend, Mr. McKie.

Mr. ROUNTHWAITE: At the outset of the discussion reference was made to Mr. McKie's slaughter-houses. I have seen the public slaughter-houses in several large towns, including Glasgow, Edinburgh, Leeds, Manchester, and Bradford, and I do not think that any of those towns can show better arranged buildings for their size, more compact, and more cleanly than those in Carlisle. Reference has also been made to automatic appliances; and I would like to have Mr. McKie's experience with regard to them. In my experience, men have to be sent periodically to attend to them. I should like to know if Mr. McKie finds them really automatic. I should also like to ask whether the butchers of the city have raised any objections to go to the slaughter-houses; whether or not they are compelled to go there; and whether the authority has licensed any private slaughter-houses within the city. With regard to the flags, I would like to know what Mr. McKie considers the leading features of a first quality Lazonby flag. I was myself struck with the point Mr. Strachan raised with regard to some of the results of Mr. McKie's tests. As to the Caithness flags splitting away, I would like to know, if in Mr. Laws' opinion, this does not arise from the inferior quality of the flags used.

Mr. CREIGHTON: I may say that the Markets Committee had a good deal of difficulty in accepting Mr. Walmisley's roof, not because they had any special knowledge of the subject, but from the magnitude of the construction. We really took Mr. Walmisley's word upon it after making many enquiries about that gentleman. We heard on every hand that he was a very competent man. As to the public baths, we take a good deal of credit to ourselves for producing a very cheap and useful institution; and I believe that any town that wants public baths cannot do better than largely adopt the plan of Carlisle baths, and thus put up a cheap, useful work. I believe the concrete work at the baths is standing all right. I may tell you that the baths are so constructed that you can walk all round them, under where the pipes are, so that if anything goes wrong it can easily be detected and put right. Coming to the slaughter-houses, I must say that I do not agree with the gentleman who criticised the size of the killing-rooms. Carlisle is an old town, and it has been very prolific in butchers; consequently, the number being great, the killing-room to be used by each need not be so large. Coming next to the question of flags, I agree with the gentleman most heartily who said that the best test was experience; and the experience of Carlisle is that no flag in the world is equal to a good Lazonby flag. I would not have a Caithness flag at a gift if I could get a good Lazonby. It may seem an invidious thing to say, but on a wet, or rather on a damp morning, you will find the water standing to the depth of a quarter of an inch on the Caithness flags; and then when you get on to the Carlisle streets, you will find them as dry as the proverbial flag. We in Carlisle are much obliged to the Association for this visit. We are glad to see Mr. Gordon, your President, who is an old citizen of Carlisle, and who, I am pleased to see, wears so well that one is inclined to think that it must be a good thing to be a civil engineer. Perhaps you would hardly think that I was a little boy in petticoats when Mr. Gordon was engineer in Carlisle. I have, therefore, no personal knowledge of Mr. Gordon in his capacity of city engineer; but I know that my father, who was a member of the Town Council in Mr. Gordon's time, had the highest opinion of him. The members of the Town Council are much obliged to the Association for the favourable way in which they have spoken of our town and officials.

The President: Most of the questions which I should have liked to have asked have been anticipated by other speakers, and on the other hand, I have heard a number of points raised which have rather escaped attention. I think I may say—and it will be the impression of the gentlemen of the Council who are with us now—that we have not come here merely to praise the city of Carlisle or its officers simply as such, but we have come here for mutual instruction, and to be of service, if we can, not only to the town and the officers of the Corporation, but to the country generally, in furnishing information likely to be useful to other towns. I do not remember a single meeting, not only during my year of office, but during my connection with the Association, at which the papers deserved greater attention than those read to-day. They are teeming with information—not information which is likely to raise points of discussion upon which Members greatly differ, but papers likely to be useful hereafter to other towns and other surveyors. That is one of the best features of our meetings. Mr. Walmisley's paper came first. It is probably an unusual thing for us to have the opportunity of criticising any works in the stage at which we find the works in Carlisle; because, suppose the criticism upon that huge roof of the market (which is a most important one) had been of a very adverse character, it might have raised a question in the minds of the members of the Corporation whether or not they had been properly advised. I am sure the Members of this Association, however experienced they may be, will always exercise a wise precaution in criticising works of which they have only a slight knowledge from a day's visit, as set against the views of the responsible officers of any Corporation, who have had a much greater opportunity of considering the whole facts of the case. On the other hand, I am sure it would be in the interests of the Corporation of Carlisle, and in the interests of the officials who have favoured us with those papers, that the questions which have been put should be fairly answered. I know of no gentleman whose experience in work of this kind I would more willingly consult in any case than I would do that of Mr. Walmisley. I believe the architects of this market have been well advised in consulting that gentleman upon so important a subject. It is undoubtedly a very important roof, and I consider the remarks made by Mr. Laws are worthy of every attention. I feel, however, that if we had the opportunity of inspecting more carefully that elaborate set of calculations which has been handed round, we should find every point raised fairly considered, and properly taken notice of. I hope that Mr. Walmisley will allow the Association to reproduce in their 'Proceedings' information which will be a valuable contribution on the subject of roof construction. Mr. Hepworth's paper on the Public Baths is also exceedingly valuable. Nothing was more easy than to give any Public Authority a rough idea of the cost of baths, when one could put one's hand upon a paper of this kind, and find that the cost was so much per square yard or so much per square foot. Mr. Creighton mentioned a point that struck me: that was, that the baths were so constructed that one could walk round them underneath. I think it is to be commended in any baths to be constructed in the future that the same facility should be given for access and inspection. I was much struck with the fact of the whole of these baths being constructed in concrete, and still further that the walls of the baths, although only 2 feet thick, and with a pressure of 6 or 7 feet of water upon them, are absolutely watertight. That struck me as a wonderful feat, and I am certain it could not be done but for the lining with white tiles. I think the city of Carlisle is to be congratulated on the work accomplished there. Mr. McKie's papers are of a far-reaching character.

I can say that I am pleased with the slaughter-houses all through. There is one thing I should like to mention. Wherever the urine of animals comes in contact with cement, it is detrimental to the cement. Nothing that I know of, except stoneware, will stand the action of urine; but here the flushing arrangements and the arrangements for cleansing are so complete, and of such a nature, that it is evident that difficulty won't arise. It was important that the concrete surface of the floor, while finished rough to give a foothold, should not be so rough as to become a receptacle for dirt. In looking at the sewer arrangements, which are excellent (and I may remark that the manholes used there are exactly of the type that were put down here thirty-two years ago by Mr. McKie, which are not improved upon to-day. Mr. McKie also read a paper on the alterations at the City Police Office. I must congratulate the town upon having effected such desirable alterations, and made such excellent provision for prisoners; and I must also congratulate the town on the possession of an excellent patent library, which must be useful to the scientific minds who have anything to patent. The paper on municipal work gives a very good review, which is particularly interesting to myself, as showing what has been accomplished by an enterprising Corporation. I think it does the past and present Town Council of the city of Carlisle great credit that such progress in the last eleven years has been made, and since I was surveyor twenty-two years ago. The works carried out since then show a grasp of the duties of a Town Council which one would scarcely expect to find in a town of the size of Carlisle. Some remarks have been made as to the great size of the public market. To the Town Council we would say, do not think it is too large, or grudge the expense. Do not think you could save a few thousands if you had not made it so large. You may depend upon it, you are erring on the right side, and that twenty years hence you won't regret it. It will be a credit to the city and to the architects, and I am sure the roof will be a credit to Mr. Walmisley. So far as I can judge, few markets in the North of England will compare with it. The paper on Lazonby and other flags shows how far Mr. McKie was ahead of the sanitary engineers thirty years ago, when he made the tests and experiments described in the paper; for these experiments held good even in the light of the scientific investigation of to-day. At the same time I must confess that I should incline to the opinion that there is no better test for stones than the absolute tear and wear of ordinary traffic. Except from a purely scientific point of view, the best test of any material I know of is to lay the materials in some well-known thoroughfare side by side, and then you will get reliable results. In regard to municipal work generally, I should like to refer to one question of great interest to the Corporation, that is the question of the ventilation of sewers. You have heard to-day something of the condition of the main sewer which passes the public slaughter-houses, and which, I suppose, carries away the sewage of a population of some 15,000 to 18,000 people. The condition of that sewer is such that no complaint can be made of any smell from that source. Mr. McKie has shown us that he takes every precaution to disinfect the sewage at that place, by the use of disinfectants from the automatic tanks; but you can at once see that if that were necessary for the whole system of sewers, it would be rather a serious matter. I think Mr. McKie says that a great number of the old manhole covers, if not the whole, have been removed since he came back to Carlisle as surveyor for the second time, and that open gratings have been substituted. Ventilating shafts have been carried up, and more tall chimneys in the city have been recently used for the ventilation of the sewers, where you could get the sanction of the owners. We know that these open gratings are much objected to in many towns; they are complained of as being nuisances, and there is now a great deal of controversy going on in regard to them. I think Mr. McKie is on the right track in utilising the tall chimneys, and if the owners of chimneys in other towns would only follow suit, the ventilation of the sewers would, I think, be improved everywhere. I believe that Carlisle in 1855 was the first to stir in this matter; and the system has been followed up to date, and now there are twenty-eight tall chimneys at work, at velocities which are perfectly marvellous. The velocities reach up to 1400 feet per minute, and even beyond that, so you can imagine what an immense amount of good is done in the way of ventilating the sewers in Carlisle.

A Member: What is the size of the pipe?

The President: It is a 9-inch pipe. In Leicester we have about sixty of the chimneys at work, and we have at present only 150 ordinary shafts carried up the sides of houses. Notwithstanding all that, we do not get rid of the complaints from the open ventilators in many places in Leicester. It would be of the greatest possible interest to know the results of the system of chimney ventilation in Carlisle. I now call upon Mr. Walmisley to reply upon the discussion.

Mr. **Walmisley**, with the aid of plans and diagrams, answered in full detail the questions which had been put. With regard to the publication of the calculations, he was in the hands of the Association, and he felt highly honoured by their appreciation. As to any strain caused by alteration of temperature, he had made calculations which showed that the strain would not be so great as one would at first sight imagine. With regard to the spandrel girders, all he had got to do—and that he had done—was to provide sufficient bearing area to take the reaction of the girders. So long as the columns remained in position, there was no fear of the girders slipping.

Mr. **McKie**: With reference to the remarks which have been made as to the slaughter-houses not being wide enough, I may say you may depend upon it, that they are wide enough for the amount of slaughtering I have mentioned in my paper to be done in them, although, in consequence of the width, I could only get one line of rail inside of the killing-rooms. As to the tests for Lazonby and Caithness flags made thirty years ago, I tried my best to put them, in regard to various characteristics, in their right positions, and at the end of my Report I prepared a digest of the results. No doubt a good deal depends upon where you get the Caithness flags. If you get top rock or inferior rock it laminates off; but in Carlisle we have had some down for twenty-five years and more. They are very hard, and have generally worn well, but they do not give a good foothold. They are non-absorbent, and they remain wet very much longer than the Lazonby flags, which absorb water, while it must evaporate from the Caithness flags. It is, however, very difficult to get Lazonby flags of the quality that we got them thirty years ago. Whole mountains have been rooted into, and now our best flags are not so good as those we used to get. The result of the drilling test was that the drill would scarcely go through the Lazonby flag at all. As has been said, the great test is the test of the tear and wear of the streets, and I say that these Lazonby flags will wear sixty years. As to the automatic flushing chambers, I find them good, but like other arrangements and contrivances of that sort, they must have attention, and if attention be given once a week they will continue to act. There are different makers of these automatic flushing chambers, and one finds that it is generally the most complicated that is least workable. I have them fixed at the Grammar School, at the House of Recovery, at the Slaughter-houses, and other parts of the town; they act extremely well, but should be examined once a week to see that the syphons are acting. The flushing of the sewers I consider of great importance, and I keep a man at that work regularly. When any complaint is made about bad smells from the sewers, I generally find they arise from some imperfect house-drains. I have two men constantly flushing the sewers, and two men and horse and cart during the summer months clearing and disinfecting the gully and manholes in the streets, lanes, and courts; in the winter months this is done by the ordinary gangs of scavengers. The sewers are only disinfected when any bad smell arises from the surface ventilators. Traps I abominate; and whenever they are put in, they should be done with care, and not placed adjacent to houses. I will add to the papers the cost per cubic foot of the buildings and other particulars asked for by the different Members during the discussion.

Mr. Hepworth: It has been said that it would be useful if the cost per square foot or per square yard of the baths had been given, and I should like to mention that that can be ascertained from the data given in the paper. Some remarks have been made as to the porosity or non-porosity of concrete. I have had considerable experience in connection with concrete work, and I have found that when I want to make a tank watertight, a good deal depends upon the skin put upon it—the finishing layer of cement. It was, however, impossible to put a skin on the surface of the concrete of the tanks at the baths, because we intended to finish with tiles. Notwithstanding that, we have practically succeeded in getting the tanks absolutely tight. Although there are one or two traces of leakage from one or two places, I attribute that to the cracking of the concrete at that particular point more than to anything else. Any leakage that has occurred, has not caused us the slightest inconvenience. As to the proportions of materials used in making the concrete, I notice that my proportions assimilate to those which Mr. Laws spoke of as most satisfactory.

On the proposition of the President, a vote of thanks was accorded to the readers of papers, and to the Mayor for the use of the Council Chamber.

The members visited the new markets in course of construction, upon which Mr. Causton offered some observations. The party then proceeded along the Castle Bank and went through the slaughter-houses, the City Surveyor showing them through the buildings. Under the guidance of Mr. McKie and Mr. Mackay, they next visited the Police-office and cells, upon which both of these gentlemen made some observations to the company. The last place visited was the Public Baths, where Mr. Hepworth acted as guide. The members then lunched together at the County Hotel, afterwards returning to the Town Hall, where the Papers were read and discussed.

ANNUAL MEETING IN LONDON,

July 12th, 13th, and 14th, 1888.

ADDRESS OF THE PRESIDENT,

E. B. ELLICE-CLARK, M. INST. C.E., LONDON.

GENTLEMEN,—I have much pleasure in welcoming you to Westminster, and in congratulating the Association on its increased prosperity and usefulness. As you have heard in the Annual Report, there has been a greater increase in the number of Members during the past year than in any year since the formation of the Association. In this connection it is to be remarked that there has been a considerable addition to the Association through the Metropolitan surveyors, who under the original rules were debarred from membership. It had long been obvious to your executive that any Association professing to represent the municipal engineering profession of this country, was incomplete without including the municipal engineers of the greatest city of the world. There is no doubt in my mind that the Association will not only be greatly strengthened in numbers, but that the Reports of its proceedings will be much enhanced from the professional point of view, by the accession of the Metropolitan engineers and surveyors.

The sphere of usefulness of the Association is being considerably extended, not only in the papers that are contributed, and which are sought for by municipal and sanitary engineers throughout the world, but also by the work which the Council have undertaken in the examination of candidates as to their qualifications to fill the office of municipal engineer and town surveyor. The rise and progress of the municipal and sanitary engineer will some day form a very interesting history in the archives of municipal authorities; his growth from the "mere mender of roads" and the "patcher of highways" to a skilled, thoughtful, and scientific engineer has occupied a period of about fifty years only. Modern requirements are such that not only in every town in the country, but in almost every village, it is necessary to have recourse to the services of a thoroughly qualified and capable engineer and surveyor. It is a mistaken notion on the part of local authorities, that because the population whose public affairs they administrate happens to be small, the works which are required to be carried out in such districts are of a simple character. It not infrequently happens that the engineering works necessary in small towns require greater engineering skill than they do in some of the great towns of the country, for the physical conditions of such small towns determine to a great extent the nature and cost of the sanitary works required; therefore it is of the highest importance for the conservation of the public health in those communities, that all public works should be designed and executed in as careful and complete a manner as possible. This can only be obtained by appointing to the office of surveyor a man who has received a good technical education, and such appointment should be the stepping-stone to those of the larger towns. Therefore none of the work which has been undertaken by this Association is of greater utility to the community than the examination of young engineers; nor can the Council more fully carry out the objects of the founders than by ascertaining that all candidates for the office are possessed of the necessary professional knowledge; and when the municipalities of this country are made acquainted with the practical nature of the examinations, they should gladly avail themselves of the services thus rendered, as it will save consulting committees a large amount of labour; and, if I may be permitted to say so, the work of ascertaining the professional qualifications of candidates is better done by a body of examiners formed of municipal engineers than by the lay committee of a town council. These examinations are already beginning to bear good fruit, for there are not wanting instances in which the selection of a candidate for a municipal office has been determined by the holding of one of this Association's certificates. But great as is this step in the advance of, and largely as this work assists "the general promotion of the objects of sanitary science," if we are to carry out to their consummation the intentions of the founders of this Association, we must go still a step further. It is a matter of primary importance not only to the advancement of sanitary science, but to the community at large, what manner of man in succeeding generations shall fill your offices. We must not be satisfied with merely examining such candidates as promiscuously present themselves to us, but we must assist in obtaining the proper candidates; and we should, as far as is practicable, lay down some guiding rules for their education.

It has long been evident that the present system or rather want of system in the training of municipal engineers in this country, is exceedingly defective. On the Continent it is usual for all engineers to receive a professional education at a technical school; in England, as you are aware, the system of pupilage obtains. It is doubtful whether the continental system is a successful one; on the other hand, the hap-hazard way in which young engineers are trained in this country, leaves no doubt that there is great room for improvement; probably a combination of the two systems would bring about better results than either the existing continental or English practice.

A youth who is intended to follow the profession of a municipal engineer should receive a sound general education at some public school, and without making invidious distinctions, I would point out the Bedford Modern School as the type of academy in which he should be educated. Special attention should be paid to the acquirement of a knowledge of physics, higher mathematics, free-hand drawing, and chemistry; and he should, if possible, master at least two modern foreign languages, preferably French and German. At about the age of seventeen he should be sent to a school of municipal engineering if such could be found, and it may be here pointed out that there is no practical difficulty in the way of establishing such a school. There might at the Crystal Palace School of Engineering, Owen's College, Manchester, Mason's College, Birmingham, the Yorkshire College, Leeds, and other similar colleges, be special courses instituted for the technical education of municipal engineers; here should be taught the elements of surveying, the use of instruments, practical mechanics and mechanical drawing, and the strength of materials. Other subjects will occur to you, but these appear to me to be the leading subjects in which the knowledge of pupils entering engineers' offices is most defective. A year or three terms passed at such a technical school would be invaluable, so that when a pupil entered a municipal engineer's office, instead of being of no service for six to twelve months, he should be useful at once. The period of pupilage should be at least four years; three years is altogether inadequate in which to acquire a sufficient knowledge of the profession to enable him to become a competent assistant on completing his articles. As the practice of our profession varies very considerably in different localities, the exchange of pupils by municipal engineers would be most advantageous; say, for instance, if a pupil articled to the borough engineer of Leeds could be transferred for the last year of his articles to London, and *vice versâ*, his experience would be greatly enhanced, and probably the employers would also be benefited by such an exchange of pupils. Each engineer will know best how to treat each pupil. It is usual for him now to commence in the drawing office and in a couple of years to go out on to works. It is doubtful if this is the best plan. A knowledge of practical work goes a great way to make a good draughtsman, for the simple reason that if a man knows what he is drawing he is much more likely to become an accomplished draughtsman than by copying drawings which to him are mere lines and colours. Perhaps the first year of pupilage should be spent out upon works. During this year the not unimportant portion of his future occupation, viz. the ordinary maintenance of roads, sewers, and buildings, should not be neglected, for it is not an uncommon thing for a young surveyor to receive an independent appointment, who has never previously superintended the paving of a street, or had any experience in the handling of workmen. The third year, after spending one year in the office, should be devoted to engineering works of as diverse a character as the district will afford. In the last year the pupil should be engaged on both office work and out of doors, assisting in the preparation of schemes and seeing them executed. At about the age of twenty-two such a young man would, with ordinary ability, be worth taking into an office at a salary, and he should be well able to pass the examination of this Association. A considerable number of candidates have presented themselves for examination, and their numbers appear to be on the increase.

It will be asked if, after all the preparation described, and a young man becomes a competent municipal engineer, is there a good prospect open to him? It is a common cry with the young men of the age, that all the professions are overcrowded. All walks in life are overcrowded with incompetent men. No profession, especially our own, is overcrowded with thoroughly competent and trustworthy men. Of the amount of work that yet remains to be done by the municipal engineer, it may be stated that during the past few years I have had as consulting engineer through my hands reports on upwards of 1000 houses in the Metropolitan area, the rateable value of such houses averaging considerably more than 100*l.* per annum. Of these 50 per cent. were in such a bad condition as to require entirely new sanitary arrangements. Now the number of houses in the Metropolitan area may be roughly taken at 750,000. If the above figures offer a true indication of the present condition of these houses, there remain something like 375,000 in London alone, in which new drainage works are absolutely necessary, and looking at the high rateable value of the houses of which mention is made, it is probable that more than this number require to have their sanitary appliances renewed. This condition of things probably obtains in a greater degree in the provincial towns.

This is only one part of the work which the future municipal engineer will have to accomplish. There is much to be done in the arterial drainage of towns, and also in the prevention of floods in the great river valleys of this country, in discovering, inventing or designing an economical pavement, which must be impervious, insonorous, durable, and non-slippery. The municipal engineer has given to the larger populations during the past forty years good water supplies, better drainage, and better paved streets, and has also instituted some systems for the removal of decaying matters accumulating round dwellings, more or less successful; but there still remains other work for him to execute before the sanitary condition of our towns is anything like perfect. We must do something more than prevent air pollution from decaying matters. The salubrity of a town, though depending very much upon the foregoing, is still incomplete while air pollution by smoke takes place as it does at present. You have lately been discussing the question of the merits of the so-called "Destructors." No doubt the economical and speedy removal of house refuse requires a practical solution, and it may be that the so-called "Destructor" is for the moment the most ready and practicable means available for accomplishing this object; but it certainly is, as its name indicates, a barbarous and unscientific system.

Owing to the cheapness and availability of fuel in this country, we pursue a method of obtaining heat in dwelling-houses, which is only one step removed from the consumption of fuel on an open hearth in the tent of the savage, and the same unscientific method of obtaining heat prevails (only in a lesser degree) in nearly all the factories of this country. By the imperfect combustion of fuel in an open fireplace, we not only do not obtain one-half of the effective value of the fuel, but we pollute the atmosphere to such a degree as to make the air of most of our cities, through a considerable portion of the year, almost insupportable. Let us conceive for one moment what a beautiful city London would be, even in winter, without the well-known London fogs, which are largely due to the presence of unconsumed carbon, caused by smoke from domestic fireplaces. Take again the Lancashire towns, from Manchester to Preston, through Darwen and Blackburn. These towns are physically situated in a series of the most beautiful valleys in England, and if they were freed from smoke their natural position would certainly render them desirable places of residence, which cannot be said under their present condition.

The future municipal engineer must therefore, among other things, pay attention to the prevention of air pollution by smoke. Many attempts, as you well know, have been made during the last half century to accomplish this object, and a few years ago an exhibition was held in London for the purpose of demonstrating that such pollution can be prevented. No doubt considerable advances have been made in this direction, but in my judgment, any attempt to overcome the difficulty by burning fuel in an open stove will end in failure. We are nearer a solution of this subject than is generally supposed. The manufacture and distribution of non-luminous gaseous fuel for heating purposes from a central station is not very far distant; by this means you will not only prevent air pollution by smoke, but you will be able in a very large degree to overcome the difficulty of removing decaying matters not passed into the sewers. If such a system were at work in a town, there would of course be few or no cinders or ashes to be removed from houses, and there should be no difficulty in designing such a stove, fed by gaseous fuel, as would in every house consume the decaying matters which now form so large a bulk of "house refuse."

There is another subject to which I am desirous of drawing your attention, and that is, to the great waste of money and time which takes place in the present method of arriving at conclusions in respect to many of the problems which a municipal engineer has to solve. Now while I deprecate to a great extent the interference of the State in commerce and manufactures, as well as in many municipal affairs, it appears to me that great benefit would accrue if assistance were given by the State, or if by a combination of the municipal authorities of this country there could be established some kind of institute or permanent commission for original scientific research. What enormous sums of money would have been saved had the disposal of sewage been taken in hand by such a commission, or been worked out by practical and scientific men keeping accurate records, and making original observations at some sewage works, as well as in the laboratory, making public reports of their observations and experiments from time to time. If there had existed such a body as this in those days when Mr. Wicksteed was laying the first sewers at Leicester, and Mr. Pilbrow was doing like work at Tottenham, now thirty-six years ago, the solution of the problem would have been greatly expedited. A large mass of information on this subject exists, but is buried in blue books and reports to sanitary authorities, and therefore not available for practical purposes. It is well worth the consideration of any Government of a State like ours, where large masses of population are aggregated together, and with this aggregation still going on at an almost alarming rate, whether some of the more difficult problems which are now attempted to be solved by individual municipalities and engineers, should not be grappled with by a state college or a commission such as I have named.

It is now more than a year since a committee was appointed by your Council to collect information and report upon the question of the ventilation of sewers. The mass of evidence that has poured in upon them is such as will require an amount of work which it is well nigh impossible for that committee to undertake, and I shall be disclosing no secret by saying that the publication of that report may be delayed a considerable time, probably years, because of the inability of the members of the committee to give that time and attention to the work which are necessary. If there were in existence a commission of experts, something on the same lines as the German Commission of Experts for the consideration of Patents, the evidence collected could be placed in their hands, the work would be expedited, and a valuable report prepared in a few months, which will now probably take years to accomplish. In the same way a great number of subjects might be dealt with, and it is for you and your immediate successors to ponder well on the establishment of such a commission as I have described.

Coming to topics which may more particularly interest Members of this Association, the past year has been a most important one in two respects. This year has seen the advent of a large measure of local government, which may have considerable influence on the future of the municipal engineer and local surveyor. Without trespassing on the domain of politics, I may confess my disappointment at the scope of the Local Government Bill. With the question of taxation and representation going hand in hand we have nothing to do, but it was greatly hoped that we should see in the Local Government Bill such a readjustment of the sanitary areas of this country as the exigencies of the case demand. It is well known that the administration of the sanitary laws is much more effective and much more economical in larger areas than it is in the small ones. The reasons are very obvious. As a rule local government in the smaller areas is left in the hands of those who do not best serve the public interests, while the administration in the larger cities is very much more complete in every respect; therefore no Bill for the local government of the country can be considered anything like perfect without a readjustment of these areas. I understand that it is very unlikely the report of the Boundary Commissioners will have any effect. It appears that so many interests have been touched, so many boundaries had in justice to be readjusted, that opposition has been excited from all quarters; but however that may be, we cannot shut our eyes to the fact that sanitary works and sanitary administration suffer very largely from the present distribution of the areas, and no measure on this subject will in my judgment be complete until all the local authorities having administation over towns of less than 10,000 inhabitants are merged into larger communities, but I am afraid this is not likely to take place in our generation, and it is very difficult to make any practical suggestion that will better the state of affairs.

Another subject which greatly interests municipal engineers has been the case of Whitely *v.* Barley. It is not necessary to enter into all the details of this case; it is sufficient to say that a surveyor, acting under distinct resolutions and by the authority of a corporation, has been mulcted in heavy penalties under the 193rd section of the Public Health Act, which was never meant to cover such cases as this. It appears now, from the decision of Mr. Justice Matthew (which has been upheld under appeal), that no engineer or surveyor of a local authority may receive any other emolument but that of his salary. It seems that this was never intended by the Legislature at the time the Public Health Act was passed, and that it is directly in opposition to the interests of the ratepayers at large. The engineer or surveyor is appointed by a sanitary authority at such a salary as is adequate for the ordinary work of a town, but there occurs from time to time a necessity for engineering works, which demand a skill and a knowledge that should be paid for, and that is paid for in other branches of our profession on a much more renumerative scale than the salaries of local surveyors; and it is positive economy on the part of the authorities to pay their local engineers and surveyors a moderate salary for ordinary work, and extra remuneration for such additional work as crops up from time to time. It was the custom to within a few years ago to employ an independent engineer to carry out most of such works; but the standard of knowledge and skill of the municipal engineer has so largely increased during the last quarter of a century, that the custom of employing independent engineers is now falling into desuetude; and I think the custom on the whole is a good one, and advantageous to the community, for however good he may be, no independent engineer can have such a complete knowledge of the requirements of the community as that official who spends the whole of his time amongst them, and therefore even if he were paid for such extra work the full percentage that would be paid to an independent engineer, it would, in my opinion, be both economical and advantageous to the community that he serves. Whenever any alterations are made to the Public Health Act, this is a matter that must not be lost sight of.

LANES, COURTS, AND BACK STREETS IN OLD CITIES AND TOWNS, EXEMPLIFIED BY THOSE IN CARLISLE.

BY H. U. McKIE, M. INST. C.E., CITY SURVEYOR OF CARLISLE.

THE city of Carlisle is one of the most ancient towns in the kingdom, the capital of Cumberland, the see of a bishop, a garrison town, and until the Union of the two Crowns, the second fortress in the kingdom.

The earliest charter on record was granted by King Henry the Second, and there is a regular series of charters from that date down to the reign of Charles the First.

Eight lines of railways converge on Carlisle.

The area of the city is 2029 acres. The population is estimated at upwards of 40,000.

The rateable value of the city in 1877 was 107,151*l.*; it is now 152,332*l.*, showing an increase of over 42 per cent.

The city is built on the main west road from England to Scotland, and is almost surrounded by the rivers Eden on north and the Caldew and the Petteril on the west and east sides of the city, the two latter rivers being only three-quarters of a mile apart at the south of the city.

A glance at John Speed's map, taken from his book of the British Empire, published in 1610 and reprinted in 1676, which accompanies this paper, shows that the King's highway from north to south, and the road to the west, formed the principal streets in the city at that time. All the houses abutted on these highways, with extensive gardens running from the houses to the city walls. No such thing as a court is shown on the plan, and only a very few narrow secondary streets and lanes from one main road to another.

It would appear from Speed's map that formerly the city elongated itself on its main thoroughfares in the same manner as I have read that some of the cities in China are built.

It must have been an advantage for the inhabitants, as they would be in touch and sight of all that passed through the city, or had business in it. Then again, the gardens would give abundant air space, be pleasant retreats ornamentally laid out, productive, and in many cases be the means by which the inhabitants approached the city walls.

The author has made a small plan of the centre of the city, showing the amount of open space the inhabitants enjoyed in 1610, as compared with the small portion of open space now left, and from which you will observe that the open space when Speed's map was made, was over fourteen times greater than the houses, and that now on the same site there are only 292 square feet of open space for thirty-eight houses, or buildings that have been used for houses, giving an average of only 7·68 square feet per house.

These lanes contain stables, second class public-houses, beer-houses, lodging-houses, labourers' cottages, cottages converted into warehouses, and until a few months ago almost all the slaughter-houses were in them, and generally placed at the end where the lane is a cul-de-sac. The lanes are over-crowded, unventilated, and often have in them back-to-back houses, or at most a small space exists of 15 to 18 inches wide for eaves-drop between the two properties, on the bottom of which is frequently deposited rubbish of a very objectionable and insanitary character.

These lanes and courts are principally occupied by hard-working labouring men, who ought to have the greatest possible amount of air space, instead of being compelled to crowd together until they have no pure air to breathe, and who must return to their hard work in the morning unrefreshed, and greedy to fill their lungs with a purer air than that breathed through the night. This state of things should not exist, and the author lives in hopes that the time will come when no man will live in these confined courts and lanes.

Now let us inquire how the parties who live in these courts suffer more than they do ordinarily when an epidemic of fever occurs in the city. During the last epidemic of fever in the city in 1874, Mr. Power, local government inspector, found that typhus located itself in forty-two lanes, courts, and narrow streets, and one broad street, with back-to-back houses in it and courts behind approached by narrow, built-over passages from the street.

Annet Square, at the north of the city, and East Street (a cul-de-sac, approached from Botchgate by a covered archway at the south), are the localities where typhus first established itself, and these two places to the north and south of the city, and half a mile apart, are the two places the fever radiated from in various directions.

It is true that since 1874 improvements have been made in these lanes and courts, but still the lanes and courts are the most favourable fever-breeding places in the city, and they are always more or less unhealthy, and during an epidemic of fever it spreads from them through the city.

Now if circumstances had allowed the city to develop itself, by following the plan of building houses abutting on the highways through the city only one deep, there would not have been such a great want of open space as at present; but being a fortified city, it must needs make room for the increase of its population, by crowding buildings on the gardens and open space within the city walls, and unfortunately, until the first Public Health Act was applied, following the same plan outside the city walls. The courts and lanes are a legacy left to the city that is not favourable to its healthiness.

Until a few years ago these lanes were occupied by the artizans of the city; but the author is thankful to say they do so no longer, but have built for themselves, or rent, outside the site of the ancient city walls, the best class of artizans' cottages and dwellings he ever saw. The author trusts the time will come when not only some of the labouring class who are now following the example of the artizans, but all of the inhabitants will declare the courts and lanes unfit for habitation by ceasing to occupy them.

The author feels deeply on this subject of overcrowding, and is convinced that the occupiers of lanes and courts cannot improve either morally or physically, if better accommodation is not found for them.

It is neither right, humane, wise, or profitable to any city or town to have these confined lanes and courts crowded with inhabitants, and to neglect to help them.

The courts and lanes in Carlisle vary very much in their character and the number of inhabitants; they contain from two to upwards of thirty tenements.

The front streets have courts and lanes at the back of them in every respect similar in construction, some of which are kept very clean and in a good sanitary condition, and are occupied by good tenants, whilst others are in a dirty, uncared-for, insanitary state, and it is almost impossible to walk up the alleys or passages of the latter lanes and courts without stepping into excrement and all manner of filth. As may be expected, the inhabitants as a rule in these insanitary courts are undesirable tenants in every sense of the word. Should an epidemic of fever or cholera at any time occur, it would be difficult to free the city of it, if these insanitary courts and lanes remain in their present neglected condition. The sanitary state of these courts and lanes undergoes considerable temporary improvement when the owners and tenants are afraid of a threatened epidemic, but after the scare is over they are soon in as bad a sanitary condition as ever.

Almost invariably when the owners live in the neighbourhood and look after their own property, or give full power to their agents, the courts and lanes are kept in as good a sanitary state as it is possible with their limited air space to keep them; but when the owners are non-resident, and their agents are not empowered to do anything but receive the rents, the properties are in an uncared-for condition throughout; the houses, gullies, water-closets, surface of court, and everything else are uncleansed, and often considerably out of repair. The Old North and South Roads have seventy-four lanes and courts leading out of them, with an average population of fifty-six in each lane or court. The Old West Road has forty-four courts and lanes leading out of it, with an average population of thirty-eight in each lane or court. The Old East Road has nine courts in it, with an average population of forty in each court.

The above roads are the principal thoroughfares and business streets at the present time.

The comparative population in the main roads through Carlisle, and in the lanes and courts from them, is as follows:—

The Old North and South Roads have only a population of 26 per cent. of that of the lanes and courts leading out of them. The Old West Main Road has only a population of 58 per cent. of that in the courts and lanes leading out of it. The Old East Road has only a population of 66 per cent. of that of the courts and lanes on it.

The average population in the above old main roads, is only 48 per cent. of the population of the lanes and courts leading out of them. The remaining streets in the city having courts and lanes leading out of them have a population of 156 per cent. of that of the courts and lanes in them. The average population of all the front streets in the city having courts and lanes leading out of them is only 97 per cent. of that of the population in the courts and lanes in them.

The total number of streets, lanes, and courts in the city which have houses in them, is 669, of which 271 are front streets, 300 lanes and courts without thoroughfares, and 98 lanes and courts which are thoroughfares, or say 40 per cent. of front streets, 15 per cent. of lanes and courts with thoroughfares, and 45 per cent. courts and lanes without thoroughfares.

There are 84 front streets (or 31 per cent. of the front streets) which have courts and lanes leading out of them, and in these 84 streets there are 398 lanes and courts. There are also 38 back streets which have only the rear of houses abutting on them, and which make the number of private back streets, lanes, and courts, 436.

The population of the lanes and courts and back streets is 13,218, being one-third of the total population of the city.

The author feels sure you will agree with him that municipal engineers and surveyors should do all they can to do away with these dwellings, unfit for human habitation, in courts and lanes, because if they are allowed to remain they will be a source of trouble and danger to the health and moral condition of the cities and towns in which they exist.

It is the author's opinion that old cities and towns which have these narrow crowded courts and lanes in them, do not and cannot compare their death-rates fairly with more modern towns, built uniformly upon sanitary principles.

Accompanying this paper you have mounted tracings of two old maps of Carlisle, a tracing of a portion of the centre of the city, one part showing it as it existed in 1610, and the other as at present, and also a complete plan of the city at the present date.

DISCUSSION.

Mr. H. P. **Boulnois**: I beg to propose a vote of thanks to Mr. McKie for his excellent and interesting paper. I should, however, like to ask him one or two questions. Firstly, as to the death-rate of Carlisle, whether it is abnormally large, and whether the death-rate from zymotic diseases is greater than in other towns. Next, as to what these lanes and courts are paved with, whether with impermeable material like asphalt, or whether with the rough cobble stones common to the North. I should also like to know whether in Carlisle they put the 150th section of the Public Health Act into force, and so compel the owners of property to make the paving of these courts as good as they can. I agree with every word Mr. McKie has said as to the absolutely unsanitary condition of buildings placed back to back in these narrow courts, which has arisen from the remarkable growth of the city. Mr. McKie mentions as one of the reasons, that Carlisle was a fortified town. I myself lived in what was once an old fortified town, Exeter; but there was nothing there of the description Mr. McKie tells us of in Carlisle. I should also like to ask him the number of persons per house in Carlisle,—I do not think he gives this in his paper,—and whether the houses in these courts are abnormally crowded for their size. I should further like to know the value of land in Carlisle, so that we may judge whether this terrible state of things has arisen from land being extremely dear; and what rentals are obtained for these miserable dwellings, placed in these wretched holes, for really we cannot call them anything else.

Mr. J. W. **Cockerill**: I shall have very great pleasure in seconding the vote of thanks to Mr. McKie. I come from a town which is very similarly circumstanced to Carlisle, as described by Mr. McKie. We have over 145 of what are known as rows or narrow passages, which provide accommodation for about 13,000. I should be glad to know what Mr. McKie does when he has plans for new buildings in these courts. We have no end of trouble and difficulties over such plans, and I do my best to get them thrown out by the Council, not always successfully.

Mr. J. **Lobley**: I have very great pleasure in supporting a vote of thanks to Mr. McKie. It is often said that one-half of the world does not know how the other half lives, and certainly the disclosures made by Mr. McKie reveal a state of things of which we had no idea. I come from a manufacturing district which is spoken of as very unattractive and not at all a desirable place to live in; but I can say we have nothing of this kind there. No new dwellings, such as Mr. Cockerill has spoken of, would be allowed to be built in a court. Every house must be in a street, and every street must be twelve yards wide. This regulation has been in force now for thirty years, so that such disclosures as have been made by Mr. McKie respecting Carlisle certainly come to me as a surprise. I shall be glad to hear Mr. Boulnois' questions answered as to character of the paving and things of that kind. I think Mr. McKie is rather too sanguine when he supposes that the labouring classes will of themselves declare these places unfit for human habitation, and desert them voluntarily. My experience has been that so long as a dwelling is left standing, however miserable, some one will be found wretched and poor enough to inhabit it. We found, in the case of the very few dwellings we have had to condemn as being too small, that as long as they were allowed to remain, people could be found who would occupy them. The only way was to take them down, either under Torrens' Act, or the Public Health Act.

Mr. R. Godfrey: I have unfortunately had personal experience of these narrow lanes and courts in another northern town, in the neighbourhood of Carlisle. I remember that in the town of Kendall, we had a smartish outbreak of smallpox, and it was aggravated by the existence of these unsanitary lanes and courts. The town of Kendal might almost have been substituted for nearly all that Mr. McKie has said about Carlisle. Kendal consists of one main street running north and south, and another street cutting it at right angles and going east and west. The principal houses are built abutting on the main streets; but the system of numbering the houses is peculiar. There is a house, say No. 5, on one side of the street, and then an entry, which is called No. 7, and the next house is No. 9. I know one case in which there are over forty tenements down such a court, with an average of from five to six people in each of them. This is one of the evils that arose in ancient times from the land being in too few hands. Land was not then available for building purposes, and so people were crowded into houses at the back of the houses forming the principal street. Mr. Boulnois has raised the question of whether the 150th section of the Public Health Act applies in such cases. I do not think, except in a few cases, that that section would apply. These lanes and courts are to all intents and purposes private property. They are *culs de sac*, leading nowhere, and you cannot deal with them. In Kendal some of them go down to the river-side, and these are thoroughfares and could be dealt with; but, unfortunately, the Town Council of the borough of Kendal were very soft-hearted, and did not like to put the poor owners to the cost and expense of making these roads. It is well that we should have an opportunity of comparing the past with the present, so that we may show our superiority where we have it. At the same time, I may say that, in this old town of

Kendal, the death-rate is remarkably low, considering the circumstances of the case, except in an epidemic. I have known the death-rate of Kendal as low as 14 or 15 per 1000, although there are scores and scores of these places that we used to call yards. For myself, I am very much obliged to Mr. McKie for having put these things on record; and I wish we had more of the ancient history of other places.

Mr. W. G. Laws: Although I am quite sure Mr. McKie will "whitewash" these courts and lanes before he has finished with them, I should like to say one or two words. It strikes me as rather singular that, for many years, the whole of the business of the Life Insurance Offices of this Kingdom were based on the mortality tables of Carlisle. It is an extraordinary thing that, with such a state of affairs as described, and with such a death-rate as we should consequently expect, these should be the tables on which insurance societies based their calculations. Some may say that this accounts for the great success of many of these societies. Mr. McKie mentions that Carlisle was an old fortified town; and it is remarkable to see the effect that a fortified town has on the buildings within it. In Newcastle-on-Tyne we have not quite the same development of courts and lanes as in Carlisle, though we have them there also; but the fortification has affected the buildings vertically. We find the buildings within the old walls are extremely high compared with modern houses. Mr. Godfrey has alluded to the low death-rate of some of these old Border towns. It occurs to me that there might be another way of accounting for it—that of the men who would have otherwise been food for disease a good many were hanged.

Mr. Jos. Gordon: I scarcely expected to have to make any remarks to you on this paper, which I had not an opportunity of seeing before I came here. I can only say, Mr. President, that I congratulate you on your year of office being inaugurated by such an excellent and interesting paper. It records a state of things which, if we are to implicitly believe every word the paper contains, we could scarcely have expected to find in any city in the present day. But although, as Mr. Laws has said, we feel sure Mr. McKie will whitewash these courts before he has done with them, I think we may also say that he has painted them almost too black. It is not very long since some of us were in the city of Carlisle. You know that, in reporting speeches in Parliament and elsewhere, or cases in the Law Courts, if the reporters get hold of a "tit bit," it speedily finds its way to the place affected. I hope the reporters in this case will not telegraph straightway to Carlisle, and hurt the dignity of the good people there by the remarks made upon this paper. I am very glad that this paper was not read at the recent District Meeting at Carlisle, otherwise I am afraid the success of that meeting would not have been so great as it was. Mr. McKie has given you some capital statistics; but some more have been asked for, and it would have been interesting if he had given us the mortality of the city now. I think it is something like 23 per 1000.

Mr. McKie: The average is about 22.

Mr. Gordon: It may have struck Members that the population, as compared with the acreage, is small. If you take the acreage, you will find it is only 20 per acre. Had Mr. McKie been able to supplement his paper with a tracing of the ancient city, with diagrams showing the population at the present time and the population of the ancient city, they would have been very interesting, because most of us know what a thickly populated place means. About 100 per acre is a fairly thickly populated area. I have no doubt this is exceeded a little in Carlisle. The worst feature in Carlisle, which is common in northern towns, is the back-to-back dwellings. I think Mr. McKie will tell you this is now abolished, and under the new building regulations cannot be perpetrated. He tells you that in 1610, the open space was then fourteen times that built upon, but that now it is really only about one-fiftieth of the buildings. This is a very reversed condition of things, and may contribute towards increased mortality. His description of the dwellings, and of the filthiness that may be found in some of these courts, is scarcely what might have been expected in the present day, and certainly ought not to be. I think he is also rather hard on non-resident owners of property. I do not know whether he expected at all that there might be any non-resident owners at this meeting; but he is a little hard on them as a body. He may have meant his remarks for a stray non-resident owner here and there. Mr. Boulnois asked whether the 150th section of the Public Health Act is put in force in Carlisle. I can say that it is, for I have myself had some very heavy bills from Mr. McKie to pay. The paper is an exceedingly interesting one on the whole, and it would be interesting to have a few more of the same kind, to show what we can accomplish in cities where there are large numbers of these courts and narrow lanes, as compared with main streets. Even in towns of a modern character, you will sometimes find a large number. In Leicester we have a considerable number of these lanes and courts, through which there is no thoroughfare, and many of the courts of more ancient date are entered by merely a narrow passage through which you can scarcely wheel a barrow. We have a population of something like 150,000, but we manage to keep the death-rate down to about 19 per 1000. Thus you see a great deal may be accomplished, even in narrow courts and lanes, by proper sanitary measures and regular inspection from time to time. I hope Mr. McKie won't get a jacketing when he gets home for having exposed the unsanitary condition of the courts and lanes in Carlisle.

The President: I should like to suggest one explanation of the comparatively healthy condition of towns such as Carlisle. It is that the area occupied by houses, such as Mr. McKie describes, is very small, and the fresh air coming in from the surrounding country has a very good effect. In fact the inhabitants who live in these courts have more fresh air than those classes who are engaged in mills or offices, and also as a rule live in much better houses, because they belong to that class of the population which spends a good deal of time out of doors. They are employed out of doors most part of the day, and the town of Carlisle being small they consequently see a great deal more of the country than the denizens of much larger towns with wider streets and greater air spaces. There is no doubt that one of the great defects of the Public Health Act of 1848, and of all subsequent legislation on the subject, has been the inability of sanitary authorities to regulate the additions to houses already existing. I do not know of a greater blot upon the building regulations of this country, than that a man having an old house with a garden attached, should be allowed to add to the house and be able to build over the whole of his property, whilst a man having a smaller property unbuilt upon, is obliged to leave a certain air space in the rear, and a certain space open in front for a street. It is a great injustice to the owners of uncovered property, and whenever the Public Health Act is dealt with by Parliament, this is one of the most prominent defects which must be amended. It is a strange thing that we have constantly cropping up evidence such as is brought before us to-day by Mr. McKie. We had it in a very prominent and concrete form brought forward by the Royal Commission on the Housing of the Working Classes. All the country was startled by the report of that commission, and what was known as "slumming" became quite an aristocratic occupation in London. Yet nothing practical has come of that report, and very little attention is now given to this very important matter. Grave subjects of this kind seem to be passed by, as if of no moment, and Mr. McKie has done great and good service by again bringing forward the question of overcrowding in town areas. It has been ripe for legislation for the last fifty years. Reports were made, now forty years ago, by Mr. Creasy and others, and yet positively there has been no legislation to remedy these evils in a practical way. Although Torrens' Act and the Artizans' Dwellings Act have been passed, there is no Act of Parliament in existence which meets practically the difficulties which have arisen in these old cities, and in some of the modern towns. It is only by cases like Carlisle being prominently brought before the public that a remedy will be devised; and associations of this kind should remind Parliament of the obligation that rests upon it with regard to the sanitary condition of portions of these ancient cities. I concur very strongly in the vote of thanks accorded to Mr. McKie, and I will now ask him to reply to the questions which have been asked.

Mr. McKie: I may say, in answer to two of the questions, that the death-rate of Carlisle averages about 20 per 1000 per annum; before the Public Health Act was applied it was 29 per 1000. The next question was whether the 150th section of the Public Health Act applies to these lanes and courts. Now the 150th section does apply, and is being applied, but not fast enough; I may be running my head against a wall in advocating more energetic measures. We are making wonderful improvements, but I want to go on a bit faster. I can assure Mr. Lobley that the reformation is carried on by the people, and that the artizans are voluntarily going out of these courts, and will not live in them. There is nothing left but the residuum of the scum, which you cannot get clear of. All men and women worthy of the name of men and women should have, and must be provided with, air space to breathe. It is the very fact of these labourers having such a craving for a supply of oxygen that you will find them getting up at half-past four and five o'clock in the morning, in order to get an hour in the fresh air before they go to work. Why? Because they are greedy of the oxygen they could not get during the night; and I want to help them to get it. They are showing that they want it, by refusing to live any longer in these places.

Some of the owners of these courts and lanes cry "Rent! Rent!" and that is about all they say and do. There are others who are very worthy men, and have assisted in making these courts, which I say in my paper have very limited air space, as healthy as these courts can possibly be made. I must remind you that these things are a legacy that we have been left. Do not think for a moment that Carlisle permits these courts to be increased. No; there must be a 40 feet street before a new house can be built in it. There has not been a street made in Carlisle during the last thirty years that is less than 40 feet wide. In Carlisle we do not permit the erection of any building in these narrow lanes and courts, and have not done so for the last thirty years. I am sorry Mr. Creer is not here, for at Lancaster, an old county town, they have reformed all the old courts and back lanes and made them more sanitary. Now they are trying for power to go and make private back yards all right. I hope they will get the power, because if people will not keep these places clean voluntarily, they should be compelled to do so.

TEN YEARS' EXPERIENCE OF THE SHONE SYSTEM.

By Lieut.-Col. A. S. JONES, V.C., Assoc. M. Inst. C.E., Wrexham.

It is very nearly ten years since the Shone system was introduced to the world in a paper read by its inventor at the Congress of the Sanitary Institute of Great Britain, held at Stafford on the 3rd October, 1878.

The writer of the present paper, a Fellow and Member of Council of the Sanitary Institute, took part in a discussion on Mr. Shone's paper on that occasion, and stated his belief that the Stafford Congress would be conspicuous in the future by its being the occasion on which Mr. Shone's new sewerage system was first explained.

He may therefore, perhaps, be allowed to look round and say how far his prophecy, then only founded upon experiments with a working model, has been justified by results in the lifting and propulsion of millions of tons of sewage, of sewage sludge, and of that, which is known in the northern counties, as pail contents.

This Association, exclusively composed of men practically concerned in the movement of sewage in all parts of the kingdom, lost no time in ascertaining the practicability and efficiency which men in such positions would naturally demand from an invention which had commended itself to sanitarians, and on the 21st June, 1879, a large meeting, under the guidance of Mr. Pritchard, then President of this Association, examined the first ejector working at Wrexham.

Messrs. Vawser and Lobley, past-Presidents, and many Members, took part in the discussion which followed inspection, and was very favourable to Mr. Shone's views.

Thus it may be anticipated that this Annual Meeting, sitting in the Metropolis within a few yards' distance from working ejectors, will take some interest in the writer's attempt to report progress, even if he should unfortunately weary some hearers with a thrice-told tale.

Of course the lifting and propulsion of liquid or semi-liquid matter by compressed air automatically admitted and discharged, or blown off, by a machine called pneumatic ejector, has always stood forth as the distinguishing salient characteristic of the Shone system, and the novelty and efficiency of that machine absorbed much attention.

But the ambition of the inventor led him to propound a complete system of sewerage and house drainage on the most scientific sanitary principles, which principles can now be applied at reasonable cost, irrespective of any of the local conditions which, in the absence of Mr. Shone's invention, have rendered it difficult or too expensive fully to observe those sanitary principles.

He also provided an automatic flush tank for the temporary storage and concentrated discharge of sewage, slops, or clean water, which has been usefully applied; but there is no other novel appliance in the Shone system, nor any departure from theoretical principles which have been laid down by other engineers.

The distinction between theory and practice is very great, and, where natural fall is deficient or absent, engineers have been sorely tempted to content themselves with sewers of deposit.

Economical considerations had also led to the construction of large tank sewers with outlets closed for many hours every tide at seaside places, besides all the other lapses from a high standard of workmanship to which underground works are peculiarly liable, and it seemed high time for a reformer to cry out for a stricter approximation to true principles.

The advantages of a separation of rainfall and subsoil water as far as possible from sewage had only lately been fully admitted by the engineering world when Mr. Shone came on the scene, and perhaps some embers from the thirty years' strife, waged by Phillips, Menzies, and others, on behalf of the separate system, were still alive. Consequently it may not have been the most judicious course to introduce a new appliance by forcibly contrasting certain existing works with estimates of others, which might have been designed in their place if the new invention had been available at the period at which those works were executed.

And the adoption of the separate system was no *sine quâ non* as regards employment of pneumatic ejectors; on the contrary, it was obviously against Mr. Shone's pecuniary interest as operating to reduce the number and size of the ejectors which would be required to lift both sewage and rain-water together in the combined system.

But enthusiasm is not unknown among inventors, and Mr. Shone naturally desired to express the true theory of his system in as perfect a manner as possible. He therefore entered heartily into the advocacy of the separate system, because it would enable him to adjust the sizes of his pipes and their gradients to a more regular flow of sewage, and to show greater economy in the drainage of any town than would be possible under the combined system.

Mr. Shone, in fact, began with the careful compilation of a tabular statement of the discharge from various sized pipes laid on different gradients, indicating at a glance those which would give a self-cleansing velocity approaching 3 feet per second, and other particulars which should be calculated on in designing works of sewerage.

For this table alone much credit is due and has been accorded to Mr. Shone by many engineers, who refer to it with every confidence, and have found it practically useful.

The table contains two columns which give the "population for which the pipes would be suitable at the various velocities, &c.," on the hypothesis that 15 or 25 gallons respectively per head per diem would be the measure of sewage produced by the population; and it has been erroneously assumed that Mr. Shone intended the theoretical figures set forth in one or other of those columns to be adopted in designing works without reasonable allowance or practical margin, whereas he only intended to bring forcibly before engineers the startling divergence of ordinary sewerage from the true theory, and to suggest closer approximation to the latter.

But independently of this misunderstanding Mr. Shone has had to contend, from the very first, with the commonly received doctrine that compressed air is a very expensive agent.

It would hardly be right to call that doctrine a prejudice, because it rests upon special facts, but it belongs to that class of fixed beliefs which are most prejudicial to early recognition of the value of inventions, which *at first sight appear to* set those beliefs at defiance.

Now the doctrine rests only on these facts, viz.:—

1. That, in all pre-ejector applications of compressed air, it has been used as a motor like steam to drive a piston, in rapid motion to and fro, in a cylinder.

2. That there is considerable waste of power, by the neces-

sary generation of heat, in compressing air beyond three atmospheres.

3. That until recently air-compressing engines were defective in design and construction.

But in the Shone system the air itself is a slow-moving piston employed to lift the sewage, and its pressure need not exceed the limit below which the waste of power is of less consequence.

This should be obvious to any one who will take the trouble to understand the action of a pneumatic ejector; but it is to be feared there are still men who think or assert that Mr. Shone disputes the three facts on which their doctrine depends, and the members of this Association can readily understand the effect of such assertions upon the minds of that class of men who find the money for works of sewerage, and have not time to study technicalities, or to expose the half truths put forward by Mr. Shone's rivals. Engineers designing works of sewerage must often have regretted being under the necessity of leading all the sewage of a large undulating area by valley lines to some common sumpt, whence the whole has to be pumped up to an outfall (situated perhaps at a lower level than the source of a large portion of the sewage) simply on account of the prohibitory expense of establishing several pumping-stations, each requiring its own engine, boilers, pumps, and attendance, on the spot.

And here in the Shone system they have the means of collecting each district's contingent of sewage by sewers at little depth below the surface, converging to a point on no lower level than that required to give good gradients to the short lengths of the district sewers, with the certainty that so soon as a regulated volume of sewage shall have collected at such district centres it will automatically be passed on to the main outfall.

This is accomplished either by lifting and discharging, into a neighbouring gravitating sewer leading to the outfall, or through a sealed pipe which may follow the natural ups and downs of a road, and in neither case is the power expended greater than that which is sufficient for lift and friction, counting the lift only as difference of level between the district ejector and final outfall, instead of having to pump the sewage back again all the height from which it has gravitated to the single sumpt as in the old system. It may be said, therefore, that the Shone system consists in the arrangement of such convenient districts, each with its own independent outfall in an ejector station to which proper gradients can lead the sewage through small self-cleansing pipes laid within a moderate depth from the surface, and in calculation of the air pressure required to lift the contents of each ejector when full either into a gravitating sewer, or through a junction with the common rising main to the common outfall.

The saving, in depth of excavation, thus effected may often cover the whole cost of ejector station and plant, and it only remains to keep up in any convenient place, central or otherwise, an air pressure equivalent to the highest lift in the system to secure the regular evacuation of all the ejectors immediately on their being filled, and without loss of power, because reducing valves adjust the pressure applied in each case.

Mr. Shone's two chief opponents have lately acknowledged the advantage of this subdivision of the area to be sewered into independent districts, by proposing a similar arrangement with hydraulic instead of pneumatic lifting power, thus preferring, in point of fact, to employ four pistons and four cylinders to accomplish the end which Mr. Shone attains with two of each.

But it is not only the extra friction involved in a high-pressure* water engine which conflicts with common sense as regards such a substitute for the pneumatic ejector, because the sewage which falls into the latter is expelled *bodily* from the bottom of the receptacle, so that no screening and accumulation of rags and heavy matter (which require constant attention at every sewage pumping station) can take place, and the ejectors can be left for days to work under a public street without being visited, while the storage and removal of foul screenings from such a situation would be an intolerable nuisance as well as a cause of expense.

Then, moreover, all the water, after it had worked the hydraulic pump, would generally have to be pumped away like so much additional sewage, and the machinery and extra thickness of pipes for the much higher pressure of water than that of air must make the cost of installation much greater in the one case than the other.

And against these arguments we have only vague references to the loss by heat in compressing air supported by arithmetical calculations founded upon very insufficient data, and all this while practical men are constantly improving air-compressing plant with a firm conviction that the power can be produced so economically on a large scale (as in the case of the Birmingham Compressed Air Company) that it can be distributed at a profit to its producers, when paid for, by those who require to use it in place of steam as a motor for small steam engines, at less cost than they can produce the steam.

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* Say 400 lb. the square inch as compared with air at 45 lb.

A fortiori must economy be greater in the case of ejectors, since the compressed air directly moves the sewage by expansive force, and forms, as it were, a continuous elastic cushion from which successive portions, exactly equal in volume to the sewage they have displaced, are cut off and harmlessly blown away.

Those who desire to realise in their minds this direct action of the air upon fluid will have an excellent opportunity of observing it in the glass working model which they will find at the Houses of Parliament Ejector Station.

The distinction between direct and the ordinary *in*direct action of compressed air or high-pressure water (as respectively exemplified at Windsor Castle and Torquay) seems to make the Shone system much more economical than either of the others. In the ejector system *two pistons and two cylinders alone are employed,* i. e. one of each for steam as prime mover and the other to compress air.

But in the old system, when the compressed air or high-pressure water, as the case may be, reaches the scene of operations, either agent has to move a third piston in a third cylinder, and finally we have the heavy pump plunger working as a fourth piston in a fourth cylinder, amid all the concussions of a solid body with an incompressible heavy fluid.

The valves may be the same for pump or ejector with, however, this important difference, as to wear and tear, in favour of the latter, that those for the pump must move over at least fifteen times more frequently than in the case of the ejector, for equal volumes of sewage lifted. We need not concern ourselves further with the recent controversy published by *Iron* on the Margate sewerage. At any rate the main object of this paper is to record the actual practical facts of the last decade, though it seemed desirable to open the matter with the above restatement of the Shone system, and to notice the bitter hostility it has encountered in one or two quarters whence it might have been least expected.

It is true that general assertions to the effect that "an enormous loss of power arises in the compression of air, as *the whole* (!) *of the power exerted appears again in heat,*" and that 25 lb. or

27 lb. pressure was required to lift sewage 10 feet on Mr. Shone's system, are palpably absurd, but when they emanate from an engineer who has made a reputation by his writings, and as an adviser of sanitary authorities, such bodies may well be falsely alarmed.

Borough engineers well know the difficulty of moving public bodies out of an old groove of practice, and can understand Mr. Shone's obligation, on the other hand, to all those public-spirited engineers and others who have seconded his effort to conquer that difficulty; but the fact is that the principle of his system is so thoroughly sound that nothing could upset it.

Eastbourne, under the influence of Mr. G. A. Wallis, C.E., and its Borough Surveyor, Mr. C. Tomes, made the first plunge with three large ejectors to drive the whole of its sewage out to sea at all heights of tide. This first installation was of course no adequate example of the system, but it established once for all the thorough efficiency of the pneumatic ejector as a remedy for tide-locked sewers, and its ability to cope with all the variations of flow due to the combined system.

Two miles and a half of large outfall sewer, which had all the inconvenience of an elongated cesspool backing up the flow of contributory sewers in the town, except at low tide, was at once entirely relieved, even at highest tide, by passing its contents through the ejectors to sea, and this improved state of things has been fully maintained for the last *eight years.*

But there remained certain low-lying areas in the town of Eastbourne, and the Sanitary Authority, fortified by experience, proceeded step by step to establish subsidiary ejector stations in these places to lift their sewage into the gravitating sewer, bringing the compressed air to work them by a pipe nearly three miles long from the original air compressors.

The first of these steps in advance of the original installation was taken in 1882, after two years' experience of the latter, the second in 1883, and the third is now in progress, all apparently supplied with power from the original air compressors, and the result of this healthy gradual advance has been to make Eastbourne a very fair example of the judicious application of the Shone system to remedy the necessary defects in one of the best examples of sewerage to be found in seaside towns as such works used to be designed ten years ago.

Mr. James Lemon, C.E., one of the earliest converts to the Shone system, and Mr. W. Gamon, borough surveyor, followed very closely on the first Eastbourne ejectors, by introducing a small one into the sewerage of Winchester, worked, as are railway brakes, by a Westinghouse air compressor.

Then Mr. Thomas Longdin, borough surveyor, started two ejectors at Latchford, near Warrington, in 1882, and four or five years later applied two other ejectors for transmitting pail contents a distance of about two miles, thus effecting a great saving in the previous cost of carting to the depot.

Mr. W. B. G. Bennett, C.E., followed with one ejector of 700 gallons capacity, for driving the effluent from precipitating tanks at Southampton against high tide, and two of 360 gallons each to lift from low-level sewers. A novel alternative use is made of one of these small ejectors to discharge the precipitated sludge from the tanks to other works one mile distant, and no difficulty has been experienced with either pail contents or sludge. Mexborough, Fenton, Campos (Brazil), Sacramento (California), Darlaston, Wednesbury, Compton Gifford, &c., followed suit with from two to five ejectors each, not to mention clubs, restaurants, &c. in London.

But in Beaumaris, on a small scale, and in the town of Henley-on-Thames, the Shone system is perhaps more fully carried out than in any other instance of its application *as yet completed*; and the following quotation from a pamphlet by Mr. F. Ball, ex-Mayor of Henley, shows how much it has given satisfaction.

"Advantages were gained (by adopting the Shone system) which it will be well to enumerate.

"1. Small sewer pipes laid with good inclinations at no great depth, watertight and mostly above the subsoil water level, discharging the sewage into an ejector where it becomes effectually trapped.

"2. The rapid transit of the sewage into an ejector before decomposition sets in.

"3. Reduced cost for flushing when that operation becomes necessary, the small sewers necessarily being more effectually flushed with less water than larger ones would be.

"4. Freedom from bad smells emanating from the manholes; for the cubic capacity of the sewers being small, the volume of air in contact with the sewage is proportionately small also, and being constantly changed through the rapid flow of the sewage, the latter cannot become stagnant and dangerous.

"5. Less risk of the spreading of diseases; the noxious matters entering the sewers of one district not being in any way communicated to another.

"6. The facility afforded of extending the system to new districts irrespective of levels in either.

"7. The reduction in cost both in the initial outlay and in the working expenses."

Such testimony as this after a year's trial at Henley, with a lift of 140 feet, must be very satisfactory to Messrs. Shone and Ault, the engineers, and Messrs. Hughes and Lancaster, the sole licensees of the patents, as all will acknowledge who know the difficulty, time, and money required to introduce a revolution in engineering practice.

But the careful investigation by a Select Committee of the House of Commons, which resulted in Mr. Shone's appointment as engineer to carry out a thorough reform of the sewerage of the Houses of Parliament, was a further guarantee of the worth of his system, and the impetus thus acquired is very great,—in fact large works in Moscow, Rangoon, Lowestoft, Heston and Isleworth, &c., show that a world-wide interest is now awakened, and among others the following engineers have either prepared or carried out, or are now preparing, schemes on the system, viz:—

Messrs. Thos. and Charles Hawkesley.
„ Bateman, Parsons, and Bateman.
„ Bailey, Denton, Son, and North.
G. Stayton, Esq., M. Inst. C.E.
E. Pritchard, Esq., M. Inst. C.E.
Messrs. Gotto and Beazley.
F. C. Stileman, Esq., C.E.
J. C. Inglis, Esq., C.E.
W. B. Bromley, Esq., C.E.
J. C. Melliss, Esq., C.E.

The works undertaken at Rangoon, in British Burmah, are very extensive, and provide not only for removing the sewage of a population of 50,000, but for a high-pressure water supply to be maintained from the same air compressors.

These and other sewerage schemes now in progress will have a discharging capacity of about 8,600,000 gallons per diem, and the fact that several sanitary authorities in different parts of the world have let contracts to provide for that aggregate amount of work shows that the Shone system has gained considerable confidence.

But work actually performed is the basis of that confidence, and it has occurred to the writer to make an approximate estimate (on the basis of population sewered) of the sewage which has been lifted by pneumatic ejectors up to the present date. This amounts to nearly 48,000,000 *tons* of sewage raised to heights ranging from 6 feet to 140 feet.

Besides this, Mr. Bennett, C.E., estimates that nearly 5000 tons of sludge have been moved one mile at Southampton, and Mr. Longdin, C.E., returns the quantity of excreta or pail contents as about 11,000 tons transported about two miles at Warrington.

Considering that four-fifths of the period of time, and a large amount of brain work and paper work have necessarily been expended in preliminary demonstration of the merits of the system, the above statement, of actual work done in moving sewage, can hardly be thought insignificant as the record of the first decade of the Shone system, while the number of ejectors already ordered and in progress is very large.

As an illustration of what the above figures mean, it may be remarked that the air pressure employed on the above work would more than suffice to remove down to Sea Reach one sixth-part of the annual flow of sewage at present discharged at Barking and Crossness, i. e. about 170 million gallons per diem for some sixty-three days.

The writer is not in a position to state the cost of the work done, or to compare it with that of lifting sewage in any other way; but the fact that so many different sanitary authorities, who have paid the cost, are generally satisfied with their experience is encouraging, and the time will doubtless arrive when some common basis of comparison may be agreed upon and results carefully noted.

Hitherto, however, so much heat and friction has arisen in argument between the advocates of low-pressure air and high-pressure water, on technical points such as the curves of adiabatic and isothermal compression, and on the efficiency of prime movers, that it is hopeless to look for speedy agreement to abide by the issue in foot-pounds and coal consumption, because wear and tear of plant would still form a bone of contention.

Under existing circumstances, therefore, the practical view of this problem must surely be "*Solvitur ambulando.*"

DISCUSSION.

Mr. Peregrine Birch (Westminster): I had intended to have deferred the very few remarks I have to make, in the hope that some gentlemen who have tried the Shone system, and have figures at their fingers' ends, would have given us the definite facts to which they could have spoken. There is no doubt the Shone system has a very good and able advocate in Colonel Jones; but I cannot say that I altogether hold the same opinion that he does. I cannot concede to Colonel Jones that Mr. Shone is the introducer of self-cleansing sewers or sealed rising mains. I should like to know what is the cost of lifting a certain number of gallons of sewage by the Shone system, as compared with the cost of getting the same quantity of sewage to the same height, by means of steam pumping, gas-engine pumping, or hydraulic power. Yesterday I had the advantage of seeing the works at the Houses of Parliament. I think we must all agree that, for cleanness, neatness, and excellence of brickwork, and ventilation and all that kind of thing, nothing could surpass what we saw. But I wish Mr. Shone, or any one familiar with the figures, would tell us whether the net average work done at the Houses of Parliament exceeds ⅛ horse-power. We have seen the gas-engine, and the air-compressing machines, and the plant, which has been arranged extremely well, but it amounts to 16 horse-power, and I should like to know whether the work actually done exceeds ⅛ horse-power. From the figures given to me yesterday, I came to the conclusion that the pumping done did not exceed ⅛ horse-power. From my experience yesterday, I am inclined to agree with the offer I am told Mr. Latham made to the Henley people, which was that if they would sell the Shone plant at one-third of what they gave for it, and give him that one-third, he would undertake to do the pumping at a saving to the rates. I believe Mr. Latham could do that. I think that this question of Shone pumping has been rather "fogged" by the introduction of the term "Shone system." I do not like the term "Shone system." Mr. Shone has invented a machine for doing his pumping, and I believe it is an extravagant machine. His object is the same as our object. Our object has long been to make our sewers self-cleansing, to avoid tide-locked sewers, to avoid stagnant cesspools, and all the rest of it, and one engineer will adopt a deep sewer, another the steam engine, another a gas engine, and another hydraulic pumping machinery. But our object is the same, and whichever of these plans we adopt, these objectionable things are to be condemned and not tolerated for a moment. Although I believe that this Shone system, as soon as people know of it, will disappear as a machine for pumping sewage, I am disposed to think that, for pumping semi-fluid like sludge, it may be more generally used than it is at present; but for pumping sewage—ordinary sewage—I do not believe, when people know what it is, they will ever adopt it.

Mr. J. Lemon: As my name is mentioned in Mr. Jones's paper I could not very well remain silent, and should like to say a few words upon it. It is quite true that I was one of the earliest converts, not to the Shone system, but to the adoption of the ejector. I think, however, the Colonel must have made a mistake in the dates, because he says it was adopted at Eastbourne in 1882, and Winchester followed very soon after. I think it was in 1878 that I finished the work at Winchester, and therefore there must be something wrong in the dates. The reason why I adopted the ejector at Winchester was this, I wanted to raise the sewage from a low level district, and I wanted to put the pumping machinery in one place and the sewage outfall in another. It is the object of every engineer to get self-cleansing sewers, and his duty is to do that by gravitation where he can. If he cannot do that, then he must lift his sewage, and he must consider what is the most economical way to do it. If he can get good gradients, running, to one outfall, why then the Shone system cannot compete with the best kind of steam pumping. But if he cannot do this, then he ought to avail himself of this very ingenious invention of the ejector. The great merit of this ejector is this, it saves in some cases very deep cuttings, because the engineer can place this power at one point, and have his pumps at various other different points. Then there is another advantage attending the use of the ejector. The engineer can place his power at any possible position; and there is always a difficulty, you know, in getting a pumping station, because everybody says it is a nuisance, whether it is or not. He can place his power at one station and his pumps at the most convenient point, and that, of course, is a very great advantage. Mr. Birch has raised a very important question. He says he wants to know the cost of lifting sewage 1 foot high by the ejectors, as compared with the cost of lifting sewage the same height by other means. I can tell you, as far as my experience goes, that the ejector is a costly machine as compared with other means of lifting. Therefore he may disabuse his mind on that point; but I say that is hardly a fair way of testing the merits of the Shone ejector. You must take all the circumstances of the case into consideration. You must compare the cost of your own old system of putting down your pumping station at one point, as against sewers of good gradients, with less deep cuttings, and the power placed at various points. If on working out the whole of the facts, and the working expenses, in each case, the Shone system is found more economical, then I say it is our duty to adopt it. But do not let us run away with the idea that, as a lifting machine, the Shone system can compare with the best pumping engines; I say that it cannot.

Mr. E. **Pritchard**: I have had, during some years now, considerable professional experience in several towns of the working of the Shone ejector. In two places in particular I have put down six of these ejectors; which are at the present time at work, some of them only partially. I think it was about 1879 that Mr. Shone made public the ejector, and I recollect hearing an explanation of it and seeing it at work, on the Wrexham sewage farm. It is only right to say that I was very much struck with it as a substitute for pumping under certain conditions. I agree with what previous speakers have said, as to the ejector compared with pumping engines. I do not believe that any system of compressed air can be made to compete with our best description of pumping engines. Although I proposed to give the ejectors a fair trial at the first opportunity, it was some years before I felt justified in advising my clients to go to what Mr. Lemon calls the expensive outlay. But the time came at last, and I can explain how it has been most advantageous for the districts where the works have been carried out. At Wednesbury, a district in Staffordshire, it was found that it would be necessary to construct a very costly intercepting sewer to convey the sewage to one outfall. We should have had to pass through ground over mines, and this only for the accommodation of a small number of the population. Now, that would have involved very expensive and costly work in every respect, as well as being work very difficult to maintain. Now, there was a case where things were in favour of the Shone ejector. The pumping station was determined upon at the outfall. The main high level sewer, which will take the greater portion of the sewage, discharges at this point. For the remaining smaller quantity of sewage, it would be a very costly thing to construct a separate sewer, consequently ejectors are used. These ejectors are four in number. Their distance from the station is between two and three miles. The ejectors are calculated to discharge, one 56 gallons per minute, another 20, another 96, and another 50, with a dead lift ranging from 11 feet to 28 feet, and the sewage will be automatically lifted by the ejectors to the high level sewer flowing thence by gravitation to the outfall. The one engine compresses the air for the ejectors, and also for the sludge-pressing machinery; operates the lime and alumina mixers, as well as other works. Consequently as one man does the whole of the work, as engine driver, there is a considerable gain by the adoption of the ejector system.

Mr. G. R. **Strachan**: When a paper is read before an Association like this, it gives great prominence to the system advocated, and I think we should emphasise our opinion that the Shone system has merits in a limited sphere for limited ends. Many of us object entirely to its being called a system, or applied as a whole system to towns. I notice there are many statements in the paper that Colonel Jones would have difficulty in establishing. One of these is, a reason which he gives why the Shone system should be adopted in opposition to other systems—that all underground works are particularly liable to lapses from the inferiority of the workmanship. What does he mean by coming here, and saying this is a disadvantage to a body of engineers? He is speaking to a body of men who know something about such things, and I think this is a great blot on his paper. Colonel Jones further says that Mr. Shone has to contend against some commonly received doctrines, and one of these is, that compressed air is a very expensive agent. I venture to say that there is a good basis of fact for this commonly received doctrine; and Colonel Jones has not said one word in his paper, from beginning to end, that will tend to remove it. I notice further, that the paper says he is going to give his practical experience of the system for the last decade, but there is not one line devoted to the expense of the system. That, however, is the real point. Reference has been made to Henley. I have the figures, as they were given to me; I will put them forward, and perhaps they will be corrected if they are wrong. The population is stated to be 5000, and the drainage from 3000 is connected with the sewers. The sewage is lifted 117 feet net, and with friction, 140 feet, as stated in the paper. Taking 30 gallons per head, and 3000 as the sewage population, that gives 90,000 gallons of sewage, and the cost of pumping, that is 450*l.* a year. That is a fact, and I give the advocates of the Shone system an opportunity of denying it. Taking five persons to a house, and the average rateable value of every house at 40*l.*, it amounts to a 5*d.* rate for pumping alone. Probably this is the reason why no figures as to the cost are given in the paper. It shows that, when the system is applied to the whole of a town, the commonly received doctrine that compressed air is an expensive medium, is a true one. The Houses of Parliament works may be the "most beautiful and clean sewage works in the kingdom," but they stand unique in being the most expensive.

Mr. E. G. **Mawbey**: I admit that Mr. Shone's system has very special merits for particular isolated cases, but I was convinced, after thoroughly going into the matter, that as a general scheme for York it would be very expensive, so far as I could judge from the data at our disposal. We felt sure if we adopted it as a general system, we should eventually have to apply the separate system to the whole of the city, and we should not be able to take in the first washings of the streets unless we carried out the Shone system on a very extensive and expensive scale. I am very glad to hear we have some data as to the percentage of power given back in actual effective work in sewage lifting. There is one thing I should like to mention. I noticed in the Houses of Parliament, when our party was there, there was considerable noise in the working of the ejectors. It is stated there is no noise made by the working of these ejectors. I am anxious to have an opportunity of introducing the Shone system in some suitable isolated district; but I should like to know why that great noise was caused, or whether it can be avoided. It struck me, Mr. President, when we were considering the York scheme, that we might very well transmit air power to an isolated low-lying district from our main pumping station, in order to work simple air engines and pumps combined, the valves being actuated by an automatic float working on the surface of the sewage. The air could by such an arrangement be used expansively.

Mr. J. **Lobley**: The same reason that Mr. Lemon and Mr. Pritchard advanced for speaking must also be my excuse for doing so. I see no reason to alter the opinions which I expressed nine years ago. I saw then that the thing was practicable, and that the system is exceedingly useful as an adjunct, and for outlying districts in many cases. A few years ago I was asked to examine the plans of a neighbouring local board in my own district, and report upon them, which I did. Although I found no fault whatever with the ordinary system adopted, it involved an outfall sewer and pumping station for which land would have to be obtained at a high price by compulsory powers. This outfall sewer would have to be constructed very deep, and to pass under a canal in two or three places, and being a very flat gradient, the pumping station would also have to be placed at that position, and another pumping station most probably on the sewage farm. I recommended the authorities of Fenton to look into the Shone system, and said I thought it would save them a considerable sum of money. They did so, and formed a committee, which visited Eastbourne, and they have adopted the system, and I believe are perfectly satisfied with it. The first cost of the deep intercepting sewer was entirely saved, that of the pumping station was entirely saved, and the pumping engine was in a measure saved, with the boilers and attendance. They placed their engines and boilers on their own land, and have put their ejectors where they liked, and I venture to say the interest on the capital they have saved will pay the entire cost of pumping. They lift the sewage on to the farm, and to the upper part of the farm, so that there is an undoubted saving by their having adopted the Shone system. Thus my opinion has been confirmed since my visit to Wrexham nine years ago.

Mr. J. Gordon: We are very much obliged to Colonel Jones for bringing the subject forward, but I feel very much the same as Mr. Strachan respecting the tone of the paper, and the way it attacks gentlemen who are named, and gentlemen who are not named. What we really want to know are the facts of the case. We want to know the cost of the works which have been referred to, so that we may form an opinion as to under what circumstances this system may be used with advantage over ordinary methods of pumping machinery. I very much agree with what was said by Mr. Peregrine Birch about the Houses of Parliament. From anything I saw there, I cannot see that the same results could not have been obtained, in a much more economical manner, by many well-known classes of pumping machinery. If time had allowed, I should have been inclined to make more remarks on this subject, because I notice there are some points which it would have been interesting to have entered into more in detail. Colonel Jones must excuse me saying it would have been well if a great portion of the first part of the paper had been left out altogether. It does not seem to be a proper way of bringing a subject of this sort before the Association to pick up all the controversies respecting it that have taken place during the last ten years. We know nothing about these things here this morning, nothing whatever. Colonel Jones says, "At any rate the main object of this paper is to record the actual practical facts of the last decade, though it seems desirable to open the matter with the above restatement of the Shone system, and to notice the bitter hostility it has encountered in one or two quarters whence it might have been least expected." This Association knows nothing about this, and I hope the remarks do not apply to the members of it. Mr. Strachan has touched on this point and on the next paragraph in the paper about an engineer having said that 27 lb. pressure was required to lift sewage 10 feet on Mr. Shone's system. It is said in the paper, that statements of this kind are "palpably absurd, but when they emanate from an engineer who has made a reputation by his writings, and as an adviser of sanitary authorities, such bodies may well be falsely alarmed." This again is a thing that does not seem to concern us this morning. We want to get to the practical facts. There is this paragraph, "Two miles and a half of a large outfall sewer, which had all the inconvenience of an elongated cesspool backing up the flow of contributory sewers in the town, except at low tide, was at once entirely relieved, even at the highest tide, by passing its contents through the ejectors to the sea, and this state of things has been fully maintained for the last eight years." We should have liked to know whether the same results could not have been obtained by lifting the sewage by ordinary methods so well known to engineers. I quite believe there are cases where the distribution of compressed air from some given pumping station, or central position of power may be economically applied, as for instance to the lifting of sewage sludge, such as I have seen at Southampton. That I think is a legitimate case for its use. Further on the whole thing is summed up, and the alleged advantages of the Shone system are stated under seven separate heads. But there is nothing whatever to prove or verify these statements. I am very sorry Mr. Shone is not here, and I think for Colonel Jones to place himself in the position of advocate of this system, before gentlemen who I hope know their business, is going rather further than we should expect. The points raised are things we all have in view, and we can accomplish them better, in the great majority of cases, without the application of this particular system. But we do want to know under what circumstances this system can be judiciously applied. Therefore I hope, whenever gentlemen are named in a paper read before the Association, they will do us the honour of being present, and give us the information we are all so anxious to obtain.

Mr. **Cooper** (Wimbledon): We are told that this is the most sanitary system of sewering towns. In the first place, it means the establishing of a number of cesspools here and there throughout the town, the contents of which are discharged now and then through the sewers. We are further told that the sewers are perfectly free from smell, but in a report of the Henley Town Council, which I saw, Mr. Woods, one of the members, asked whether the engineer of the works had reported as to flushing the man-holes in the town, some of which were most offensive. Again, we have a large increase in the death-rate of Henley since this system was established. The death-rate in 1880, before Shone's system was established, was 17·8. In 1887, that is after the Shone system was adopted, the death-rate rose to 19·7. In Henley they pump their sewage up to a considerable height, and on to permeable ground. It appears to me, after looking at the Ordnance sheet, as if the sewage which is pumped on to this permeable ground very likely finds its way into some of the wells and perhaps into the waterworks wells. The figure which Mr. Strachan gave—namely, that the cost of these works was 486*l.* a year, does not appear to include the interest of the capital expended. If it does, it only includes 75*l.*, and that could not in any way represent the interest on the outlay for the pumping station and Shone's injectors, nor the two engines of 35 horse-power, for pumping the sewage of 5000 inhabitants. It seems ridiculous such a small population should want such powerful engines. Two six horse-power engines ought to have been quite sufficient.

Mr. G. E. **Eachus**: I submitted a plan of the Shone system for Hâvre, and also an ordinary sewage scheme. The ordinary sewage scheme was an estimate and plan of my own, the Shone scheme and plan were prepared by Mr. Shone, and the estimates of first and annual cost by Mr. Hughes, of Lancaster. The actual figures, in that particular instance, worked out a little, but not very much, against the Shone system. I was not then in possession of the facts which have come to my knowledge since with regard to the actual cost of the pumping. I would ask the reader of the paper, or Mr. Shone, to furnish us with a few facts which they can give for fixing the actual comparative cost of the two systems. If they would give the area, population, and actual volume of sewage pumped in one particular place, the area served and fall of sewers in each division, and the height of the nett lift, and the increased height of lift at each injector—if they would also give the detailed cost, I think we should then be able to make a comparison which would be more satisfactory than anything we have yet had put before us.

Mr. **Joseph Hall**: Torquay has been referred to as having an alternative system of pumping from the mains. In our case the water runs off direct into the high-level sewer. The cost of water never exceeds 120*l.* a year at 4*d.* per 1000 gallons, and the cost for labour never exceeds 20*l.*, for attention, repairs, and incidental expenses. The maximum duty of the pumps when both are working is 14,000 gallons per hour lifted 16 feet, but usually only one pump is required for a part of each day, and they work automatically, starting and stopping as the flow of sewage varies. The population served is about 2000, and one-third of the storm-water is included.

Mr. E. J. **Silcock**: The first speaker asked what was the average power that is being used at the Houses of Parliament for pumping the sewage there. He said he calculated theoretically the power which ought to be used at one-eighth horse-power. Whilst there I asked the gentleman who accompanied us what amount of power was being used, and how much it cost per hour per horse-power. The result of my inquiries came to this, that when the ejectors were being discharged 4 horse-power was being used, and when they were not being discharged, 2 horse-power. Consequently it takes 2 horse-power constantly running to keep up the power in the accumulators.

Mr. F. **Ball** (Henley-on-Thames): I am a member of the Town Council of Henley, but I am sorry to say I have come here without some papers which would have given you the information in detail. But from memory I can tell you that the annual working expenses for fuel, labour, and such things is about 480*l.*, and that the cost of fuel per indicated horse-power per hour, at the present price of coals, is ¼*d.* The rate for the repayment of the loan, interest and working expenses amounts to 2*s.* 2*d.* in the £ per annum—1*s.* 1*d.* per half year. That is against rates of 2*s.* 6*d.*, 3*s.* 1*d.*, and 3*s.* 6*d.* in the £ respectively, the estimated annual cost, but not including interest on purchase of land, for schemes submitted on other lines. So that instead of the Shone system being more expensive, it is really very much cheaper than the system of ordinary gravitation and pumping would have been. That is an actual fact; there is no supposition about that. One gentleman said that the population of Henley draining into the sewers is 3000. The number must be nearer 4000 of the resident population, and during the regatta week we have had the sewage of 10,000 or 12,000 persons to deal with. Not only does the resident population of the town increase, every residence, and every little cottage—as your President is aware—being crowded at that time, and all the large hotels likewise, but in addition, large numbers of persons come in by trains, who go to hotels and other places for refreshment; which necessarily largely increases the quantity of sewage. I am pleased to say that, notwithstanding this, during the regatta week there has been no hitch whatever, and all the sewage has been regularly delivered at the outfall works without any extra consumption of coal. I can only show the advantages of the Shone system by comparing it with others that were proposed on the old pumping system. We have been enabled to take the outfall works three times the distance from the centre of the town, with three times the lift, at a less cost. The annual expenses are also less. You will all admit that it is a great advantage to have the outfall further away from the town. The outfall in the scheme proposed by another engineer, under the ordinary system of pumping, was practically speaking within the limits of the borough. If the boundary had been more like a circle instead of having large angles, that outfall would have been within the borough boundary. We have been able to take it 1½ miles away from the borough, between two hills, in a wood, where it is no nuisance to any one. The total outlay will not be more than 20,000*l.*, including the purchase of land, subsoil drainage, fee of 250*l.* paid to Mr. Latham for the rejected schemes, and legal expenses. The least expensive of the other schemes would have been something like 26,000*l.* The population is slightly under 5000, but, as I have explained, we have a greatly increased population at certain times of the year. Therefore it is hardly fair to compare the cost when the minimum amount of work is being done, and say it is dear. We must provide for the maximum, and if you take the cost when the maximum work is being done and compare it with that of steam, you will find the comparison in favour of the Shone system.

Mr. **Gordon**: Can you give us the quantity pumped per day, and what becomes of the storm water?

Mr. **Ball**: The quantity pumped per day must be about 100,000 gallons, as the waterworks company supply above that quantity daily. The storm water and subsoil water flow into the river. The delivery of sewage at the outfall was at the rate of 200 gallons per minute. The nett lift is about 120 feet.

Mr. **Eachus**: Did the other systems include the cost of land?

Mr. **Ball**: No, they did not. The lowest estimate was 17,000*l.*, without the cost of land; and in that case the cost of the necessary land would not have been less than 10,000*l.* In another case the cost would have been 19,500*l.*, and the cost of the land would have been about 2000*l.* more. In the third case the estimate was 20,000*l.*, and the land would have added 6000*l.* or 8000*l.* to the cost.

Mr. A. M. **Fowler**: A great deal of this time would have been saved if we could have some unit of cost, because we do know the cost of pumping sewage. My experience of the cost of pumping water at Leeds was, that we could pump it 240 feet high for ½*d.* per 1000 gallons. Now if we could get facts like that respecting the working of the Shone system, with interest on the capital expended, and repayment of the capital in thirty years, we should have something tangible. We should like to get from Messrs. Shone the exact cost unit, so as to have it on our Proceedings.

The **President**: I am sorry to say that this discussion, which has been very interesting, must be brought to a close, and have only one or two remarks to make myself. I spent the greater part of last week at Henley-on-Thames, and certainly a more stinking town than Henley was, during those two or three days, I never was in. It was so bad at the cottage I took that all the windows had to be closed; and I wrote a letter to the Mayor, and told him (I did not then remember that a paper was to be read on this question) that the stench was so bad I should mention the matter in my Presidential address to this Association. This may or may not be due to defects in Mr. Shone's system or so-called system; but I may say this with regard to Henley, that if Mr.

Shone is responsible for the way in which the drains are ventilated, all I can say is that it is the worst bit of engineering I ever saw in my life. I took a cottage in a street about 200 yards long—a street of cottage houses. As far as I could tell there was one sewer in front of these cottages, and another at the back.

Mr. **Ball**: No.

The **President**: I am glad to be corrected. All I can say is, that at the rear of this particular street there were 3-inch pipe ventilators, about 7 feet high, and within 15 feet of the bedroom windows. There were four of these ventilators to each row of cottages, and they also abounded in other places in the town. It is a great pity when a paper on a new system is brought before the Association that it should be submitted by a special advocate; and there is not sufficient evidence brought forward by the inventor to engineers that all the statements made are absolutely correct. As a matter of fact, Mr. Fowler has touched the keynote of the whole discussion. We want units for comparison, and without these the whole of this criticism is absolutely barren. With regard to compressing air, during the last twelve months I have had a great deal of experience. We shall show you this afternoon pumps which are constantly compressing air up to two and three thousand pounds to the square inch. I would just say this respecting it, that it is an extravagant method of obtaining power, because you are always pumping against the accumulated pressure.

Colonel **Jones**: First of all, I beg to express my thanks for the attention which has been paid to this paper, and the discussion which has arisen on it. The principal object in my mind in preparing this paper was to try and put a little oil upon all the friction which has arisen respecting this system from the first. I have always been driving at it, that the name of Shone was a curse to the system. It has been so to this day, and we can see it now influencing every speaker with few exceptions. Really cannot we banish it? I am a radical in politics and everything else, and I dissent distinctly from these trade-unionism feelings. "Great is Diana of the Ephesians" is the cry which has been raised ever since 1879, when Mr. Shone first introduced his system. It is all simply this, have we got fair-play? With respect to the date referred to by Mr. Lemon, I acknowledge that I have made a mistake, and that he adopted the system earlier. My only visit to Winchester occurred in 1882, and the date got into my paper in that way. I think nothing can be more satisfactory than Mr. Pritchard's evidence. It is nearly everything I have ever said about the system. I think it is a mistake to have a contention as to its being cheaper than any other mode of pumping until we have proper data to go upon. Attention has been called to the last paragraphs in the paper. I ask you whether it is fair to expect that the inventor of a new system (introduced with immense difficulty, and which has not been more than two years at work, in its entirety as a system) shall be bound *at once* to prove superior economy before saying anything of the undoubted sanitary advantages of his system. Some members appear to demand this, but I do not think it reasonable, and therefore I ended the paper with the view that we must wait for results patiently, and be ready to give the system fair play until we can get proper results. I think the evidence we have had here to-day, from those who have come casually to this meeting and have tried the system, is sufficient to justify my paper. I do not know that you could have anything more satisfactory than Mr. Lobley's statement respecting the application of the system to Fenton, which is quite new to me. I call that a most judicious application of the system. We speak of it as the Shone system, because it is known by that name, but it is really the application of the ejector wherever it is desirable to put it. I do not think even Mr. Shone means to put down ejectors where they are not wanted. Wherever you can gravitate the sewage with a velocity of 3 feet per second to one general outfall, no one in his senses would want to adopt the Shone system. As to noise, that is one of the objections raised, but you cannot have a valve moving over without noise, and you must put india-rubber over it if you wish to avoid noise, but it is so slight as to be of no consequence. As to the President's remark respecting compressed air being an expensive power, we all know that is so when you compress air to two or three thousand pounds to the square inch, but I ask is that a fair argument as to the expensiveness of a system which only requires 50 lb. pressure at the utmost. Another point I must just mention. Mr. Gordon referred to my having quoted, as palpably absurd, the statement that 25 lb. or 27 lb. pressure was required to lift sewage 10 feet on Mr. Shone's principle. It arose, I believe, in this way. Some one went to Warrington to see the ejector there, and he noticed the compressed air gauge stood at 25 lb. pressure, and that the sewage was only being lifted 10 feet. He did not know that compressed air was being used at the time for other purposes, and that 5 lb. or 6 lb. would have been ample for the lift required, and it was truly absurd to jump to the conclusisn that all that waste of power was necessary under the Shone system. Consequently I was obliged to say that the statement made about this was "palpably absurd."

THE AVERAGE METER SYSTEM.

By GEO. R. STRACHAN, Assoc. M. Inst. C.E., Chelsea.

The writer has been experimenting with regulator gas-burners for some eighteen months, with a view to ascertain their reliability under various and varying pressures and conditions, and in the course of the experiments doubt has been raised in his mind as to whether the average meter system is necessary to a reliable and economical determination of the volume of gas consumed in the public lamps. His object in bringing the subject before the Association is to obtain the criticisms of the members on his conclusions, in order that the true system may be revealed.

The average meter system as practised in the Metropolis is briefly as follows:—Each lamp is provided with a regulator gas-burner which passes a definite quantity of gas per hour under the varying pressures in the mains, and at certain lamps, carefully selected by the gas company and the local authority, meters are fixed, which record the volume of gas burned. Each month the meters are read, and after striking out the returns of those which show a variation of 10 per cent. over or 10 per cent. under the theoretical volume obtained by multiplying the number of hours during which the lamps were lighted into the cubic feet per hour to which the burners are set, an average consumption is obtained for the selected lamps, and this is taken as the consumption for each lamp throughout the district. The question raised is, are the regulator gas-burners sufficiently accurate to be relied upon for the quantity burned without the check of the meters?

In the following experiments an experimental gas-holder and minute clock by Parkinson were used. When the burner experimented on was fixed over the meter, it was not removed until the experiment with it was completed. In each experiment the gas-holder was filled with 5 cubic feet of gas, and was not refilled during the time, so as to secure as far as practicable gas at the same temperature and barometric pressure. The increase of temperature in the gas by the increased pressures is common to all the experiments, so that they give a basis of comparison when this slight error is neglected. The water gauges on which the pressures were recorded are four inches below the regulators. The regulator gas-burners experimented on were bought in the open market without the knowledge of their makers, so as to avoid specially prepared burners, and it is possibly due to this that the results obtained present discrepancies. The names of the makers are not stated in the paper, as the writer does not approve of using the platform of the Association as an advertising medium. The aim of the tests was to find out whether the regulators controlled the consumption of gas under varying pressures at the volume to which they were fixed. The pressures given are water-pressures: thus, 1 inch is ten-tenths pressure, &c.

Experiment 1.

Burner used was a 5-foot fish-tail common burner, said to be a "regulator," but possessing no regulating apparatus whatever. The figures under the pressures give the number of cubic feet per hour.

	PRESSURES IN INCHES.							Averages.
	1	1·5	2	2·5	3	3·5	4	
A	7·12	8·85	10·70	11·55	12·82	13·52	14·55	11·30
B	6·55	7·67	10·12	10·82	12·00	12·65	13·30	10·44
C	6·58	7·86	10·17	10·75	11·85	12·95	13·87	10·57
Averages	6·75	8·13	10·33	11·04	12·22	13·04	13·91	10·77

These results show that the burners are not regulators. The vertical column of averages shows the greatest variation to be 7½ per cent. The horizontal column of averages shows that the burners at 1 inch pressure passed 35 per cent., and at 4 inches pressure 178 per cent. more gas than they were marked to do.

Experiment 2.

Burner used was a 6-foot bat's-wing common burner, said to be a "regulator" but possessing no regulating apparatus whatever.

	PRESSURES IN INCHES.							Averages.
	1	1·5	2	2·5	3	3·5	4	
A	8·87	11·05	12·87	13·77	14·77	16·25	16·70	13·47
B	7·70	10·03	11·50	12·75	14·10	14·95	16·22	12·46
C	8·40	10·85	12·20	13·20	14·52	15·50	16·55	13·03
D	9·38	11·52	12·42	13·65	15·00	16·10	17·90	13·71
Averages	8·59	10·86	12·25	13·34	14·60	15·70	16·84	13·17

The vertical column averages show the greatest variation to be 9 per cent., the horizontal column averages show that at 1 inch pressure the burners passed 43 per cent., and at 4 inches of pressure 181 per cent. more gas than they were marked to do.

Experiment 3.

Burner used was a 5-foot public lamp regulator burner with a regulating apparatus.

	Pressures in Inches.							Averages.
	1	1·5	2	2·5	3	3·5	4	
A	5·82	5·51	5·55	5·47	5·36	5·16	4·98	5·41
B	5·33	5·30	5·23	5·17	5·08	4·85	4·60	5·08
C	5·43	5·47	5·31	5·15	5·05	5·03	4·85	5·18
Averages	5·52	5·43	5·36	5·26	5·16	5·01	4·81	5·22

The vertical column averages show the greatest variation to be 6 per cent., and show carelessness in manufacture. The horizontal column averages show that at 1 inch pressure the burners passed 10·4 per cent. more, and at 4 inches of pressure 4 per cent. less gas than they were marked to do, or a total variation of 14·4 per cent. They also show that the regulating apparatus checks the waste of gas at increased pressures, but that the burners are not true regulators, for the volume of gas passed falls off gradually as the pressures increase.

Experiment 4.

Burner used was a 4-foot public lamp regulator burner with a regulating apparatus.

	Pressures in Inches.							Averages.
	1	1·5	2	2·5	3	3·5	4	
A	4·27	4·57	4·47	4·48	4·45	4·47	4·47	4·45
B	4·18	4·35	4·37	4·32	4·25	4·35	4·36	4·31
C	4·33	4·43	4·50	4·40	4·41	4·40	4·37	4·41
D	3·95	4·06	4·11	4·32	4·22	4·06	3·87	4·08
E	4·30	4·31	4·29	4·32	4·28	4·30	4·12	4·28
F	4·31	4·35	4·40	4·40	4·37	4·37	4·38	4·37
Averages	4·22	4·34	4·36	4·37	4·33	4·32	4·26	4·32

The vertical column averages show the greatest variation to be 9·25 per cent., and show considerable carelessness in manufacture. The horizontal column averages, which reveal the reliability of the principle of the regulating apparatus, show that at 1 inch pressure the burners passed 5·5 per cent., and at 2·5 inches of pressure 9·25 per cent. more gas than they were marked to do. A study of the figures will show that the regulating apparatus is a good although not a perfect one. The consumption of gas increases with the pressure from 1 inch to 2½ inches, and decreases from 2½ inches to 4 inches, but taking the average of the experiment as a standard the burners show an excess consumption of 1·15 per cent., and a deficient consumption of 2·3 per cent.: which is a good result.

Experiment 5.

Burner used was a 4-foot public lamp regulator burner with a regulating apparatus.

	PRESSURES IN INCHES.							Averages.
	1	1·5	2	2·5	3	3·5	4	
A	4·18	4·35	4·35	4·33	4·28	4·28	4·32	4·30
B	4·35	4·48	4·56	4·52	4·68	4·63	4·52	4·53
C	4·23	4·30	4·32	4·32	4·33	4·37	4·33	4·31
D	4·13	4·18	4·31	4·30	4·20	4·27	4·22	4·23
E	4·22	4·30	4·37	4·35	4·40	4·37	4·12	4·30
F	4·41	4·47	4·57	4·65	4·63	4·63	4·80	4·59
Averages	4·25	4·35	4·41	4·41	4·42	4·42	4·38	4·38

The vertical column averages show the greatest variation to be 8 per cent., and show considerable carelessness in manufacture. The horizontal column averages show that at 1 inch pressure the burners passed 6·25 per cent., and at 3 inches of pressure 10·5 per cent. more gas than they were marked to do. They also show that the regulating apparatus came somewhat slowly into action, but that for pressures of 1½ inches and upwards it is as near perfect as can be expected; the variation from the average not exceeding 1 per cent. on either side.

Experiment 6.

Burner used was a 6-foot household regulator burner with a regulating apparatus.

	Pressures in Inches.							Averages.
	1	1·5	2	2·5	3	3·5	4	
A	6·57	6·60	6·70	6·57	6·27	6·17	5·67	6·36
B	6·57	6·60	6·65	6·63	6·57	6·30	6·10	6·49
C	6·18	6·51	6·62	6·78	6·51	6·55	6·46	6·52
D	6·16	6·41	6·62	6·50	6·30	6·31	5·80	6·30
E	6·27	6·51	6·63	6·71	6·60	6·51	6·15	6·48
F	6·26	6·30	6·55	6·62	6·37	6·23	5·80	6·30
Averages	6·34	6·49	6·63	6·64	6·44	6·34	6·00	6·41

The vertical column averages show the greatest variation to be 3·4 per cent. The horizontal column averages show that at 1-inch pressure the burner passed 5·7 per cent., and at 2·5 inches of pressure 10·7 per cent. more gas than they are marked to do.

A number of other experiments were made, but they do not present new features, except the one which tested the burners to discover the pressures at which the regulators came into action. None of the regulators came fully into action at a pressure below six-tenths of an inch, and most of them at eight-tenths. The nett result of the experiments given is that regulator gas burners can be made which will not vary in their consumption of gas at pressures varying from 1 inch to 4 inches more than 1·15 per cent. fast and 2·3 per cent. slow of their average consumption. All that is necessary therefore is to get the regulator accurately set, and its limits of error are known. The Metropolis Gas Act, 1859, defines a meter as correct which does not register more than 2 per cent. fast and 3 per cent. slow. The gas-room tests given herein show that regulator gas burners can be made as correct as gas meters.

The question now arises—Do regulator gas burners in use on public lamps, where exposed to all weathers, temperatures, and barometric pressures, give equal results to those found in the testing room? The writer is honoured by Mr. Philip Monson, the gas superintendent for the parish of Kensington, placing at his disposal the results of the average meter system for eleven years. Each lamp has a regulator burner set to burn 4·5 cubic feet per hour. The meters are read each month and the records have been carefully collected. More than 4000 lamps are in lighting on the meter system. The following table shows the average consumption per lamp per hour for each of the eleven years.

1877	4·55	cubic feet	per lamp	per hour.
1878	4·57	”	”	”
1879	4·50	”	”	”
1880	4·43	”	”	”
1881	4·46	”	”	”
1882	4·50	”	”	”
1883	4·48	”	”	”
1884	4·49	”	”	”
1885	4·49	”	”	”
1886	4·52	”	”	”
1887	4·54	”	”	”
	11)49·53	”	”	”
Average	4·503	”	”	”

These results are a convincing proof that regulator gas burners may be relied upon in actual use. The writer has compiled the following table from Mr. Monson's records, showing the average consumption per lamp per hour for each month of the 11 years.

January	4·38	cubic feet	per lamp	per hour.
February	4·51	”	”	”
March	4·45	”	”	”
April	4·53	”	”	”
May	4·49	”	”	”
June	4·61	”	”	”
July	4·60	”	”	”
August	4·53	”	”	”
September	4·53	”	”	”
October	4·49	”	”	”
November	4·50	”	”	”
December	4·39	”	”	”
	12)54·01	”	”	”
Average	4·501	”	”	”

It will be noticed from this table that the lowest consumption occurs during those months when the hours of lighting are longest, and that this gives an advantage to the local authority if the average meter system is adopted. The following table, based on 4300 hours' lighting per year, shows the amount of this error.

Month.	Hours of Lighting.	Cube Feet per Hour.	Total Cube Feet per Lamp.
January	484·03	4·38	2120·0514
February	397·75	4·51	1793·8525
March	375·58	4·45	1671·3310
April	303·90	4·53	1376·6670
May..	260·41	4·49	1169·2409
June	224·52	4·61	1035·0372
July..	246·30	4·60	1132·9800
August	294·01	4·53	1331·8653
September	341·90	4·53	1548·8070
October	414·67	4·49	1861·8683
November	454·95	4·50	2047·2750
December	501·98	4·39	2203·6922
Totals, &c. ..	4300·00	4·50	19,292·6678

If the consumption had been taken from the burners alone, it would have stood at 4300 × 4·5 = 19,350 cubic feet per lamp per year, as against 19,292·6678 cubic feet given by the meters, or an error in favour of the gas company of 57·3 cubic feet per lamp per year. In London the price of gas to public lamps north of the Thames is 2*s.* 2*d.* per 1000 cubic feet, so that the saving to the local authority for gas by the average meter system is 1½*d.* per lamp per year.

Against this there is the cost of the average meter system. The following figures refer to a district containing 4000 lamps with a meter to every 20 lamps.

CAPITAL EXPENDITURE.

	£	s.	d.
200 meters fixed complete @ £7 10*s.* each	1500	0	0

ANNUAL EXPENSES.

Interest, depreciation, and repairs on meters, 10 per cent. on £1500	150	0	0
Man's time reading meters: 12 weeks per year @ 25*s.* per week ..	15	0	0
	165	0	0

This cost divided over 4000 lamps equals 9·9*d.* per lamp per year which is incurred to save 1·5*d.* per lamp per year.

The figures given refer to a district where the minimum parliamentary limits of pressure are ten-tenths from sunset to midnight, and six-tenths from midnight to sunrise. As a matter of fact, however, the actual pressures are in excess of these limits. From the continuous recording pressure gauge in the testing room at Chelsea it is found that the pressure does not get below 1·2 inches at any part of the day, and that from one hour before sunset to half an hour after, the pressure rises to 3 inches and even more, and then gradually falls to 1·4 inches by midnight. Where pressures like these are given, the writer is of opinion that the average meter system is an unnecessary check and expense. It may be that in small districts the pressures fall below those stated as the parliamentary limits, and in such cases the regulator burners would not pass their full quantity. The remedy, however, is to make the gas company give a proper pressure, and so save the expense of the meters.

DISCUSSION.

Mr. J. **Lemon**: I think we are very much indebted to Mr. Strachan for his very valuable paper; but I must say that the conclusions he draws are not in accordance with my own experience. If you can get a gas-regulator perfectly made, as he says, then it will do very well indeed, but my experience is that there is no such thing as a perfect regulator. The best is only an approximation, and is only intended to be a check upon the consumption of gas when there is great pressure. The principle of the regulator, as you all know is, that when there is a great pressure of gas, it temporarily checks the supply, and so regulates the supply to the burner. Such a regulator as that must only be an approximation to regulate the consumption of gas. As regards meters it is quite true that the percentage of their correctness is two one way and three the other; but you know you must have some kind of margin. You cannot expect that every person will have an absolutely correct meter, and therefore this small margin of 2 and 3 per cent. is allowed in testing meters, so as to provide against the irregularity which must occur in the working of every mechanical appliance. I take exception to the annual expenses—interest, depreciation, and repairs—10 per cent. on 1500*l.* I introduced the average meter system into my borough. Mr. Bennett is here, and perhaps he could give you better information on that subject than I can; but it never at any time cost anything like 10 per cent. for repairs to meters. I think that is an outside estimate altogether. Then, as regards men's time for reading the meters; I used to employ one of the assistants in the office to go round with the man and check the meters, so that it was no extra cost to the borough. If we had to stop the gas-testing to-morrow, we should not reduce the salaries. It is done by the staff in the office, and you must expect to do these things, for I consider it the duty of a Surveyor to do all that he can for the benefit of his borough. Therefore I think the item of 15*l.*, although it is only a small amount, ought to be struck out. On the face of it, it looks rather absurd to spend 9·9*d.* per lamp, nearly 10*d.* per lamp, to save 1½*d.* per lamp; but what I say is, that the gas regulator is unreliable, and that it is necessary to have a meter to get anything like a fair record of the consumption of gas. The gas-meter is, as far as I know at present, the only reliable record, and the gas-regulator is not to be depended upon.

Mr. Jos. Hall: Mr. Strachan raises the question of whether gas-regulators are reliable or not without a meter. My experience coincides with that of Mr. Lemon that they are not. But, though I would never attempt to use them alone, a regulator is absolutely necessary as a check upon the men. The lamplighter puts the metered lamp as low as he possibly can, and all the others full on, because it is less trouble than to regulate each one. All that is necessary is to get the regulator correctly set, and its limit of error is known for two days; but in cold weather naphthaline deposits on the float, and you get it an appreciable degree heavier. Then with regard to the cost; the capital expenditure of 1500*l.* seems to me to be an excessive amount for the size of meters that are ordinarily used for street lamps. The depreciation, 10 per cent., is more than usual, and more than my experience works out. As to reading the meters, we check them four times a year. I go round myself and read off the whole of the 52 meters for 600 lamps and make up the account in an afternoon. I could not depend upon an ordinary workman to do this, and I do not think it would be desirable to do so.

Mr. Thos. Farrall: We have in our town the average meter system. We have 148 meters. They are the property of the Board, and I read them once a quarter, and it generally takes me about an hour and a half to do so. The meters have not cost us anything at all for repairs during the eight years that they have been in use. Whether it is the fault of the gas company I do not know, but they are perfectly satisfied with the registration, and we get on comfortably with them. There is one extraordinary thing with respect to governors I may name. We have one all-night lamp at the top of a street 400 or 500 yards long, and another at the bottom of it. The gradient is something like 1 in 20, and therefore we should expect that the lamp at the top of the street would consume more than the one at the bottom; but it is quite the reverse, as we generally find that the one at the bottom consumes from 15 to 20 per cent. more than the one at the top. That I daresay is accounted for by the governors not working quite regularly. They are taken down and examined once a year, and I think we pay altogether for this about 12*l.* We used to pay the gas company 2*l.* 10*s.* for each lamp when we contracted with them for the lighting, and now the cost is about 1*l.* 5*s.* per lamp.

Mr. W. B. G. **Bennett**: I should like Mr. Strachan to tell us whether the lamps are all on one level, and, if not, can he give us the different levels? With respect to 10 per cent. for repairs and depreciation, I find, in the borough of Southampton, it is more like 4 per cent.

Mr. G. E. **Eachus**: The point of comparison is, the expenditure for gas with and without a meter. The cost for checking consumption is 165*l.* on an expenditure of 8000*l.* for 4000 lamps. That is equal to 2 per cent. on the expenditure. The way in which an engineer would look at this would be, that he would regard it as a small expenditure to check a large one.

Mr. J. P. **Norrington**: In experiment No. 3 a five-foot regulating burner was used by Mr. Strachan; and in experiments Nos. 4 and 5 four-feet regulating burners were used. I should like to know whether five-foot regulator burners of the same kind as used in experiments Nos. 4 and 5 were tested, and what results were obtained. The statements before us leave it doubtful whether the irregularity of the results shown in some of the experiments might not have arisen from the differences in the sizes of the regulating burners that were tested.

Mr. T. **Gledhill**: My experience has been that regulators are not to be depended upon. We have far more trouble with the regulators than with the meters. The gas inspector is continually going round, and finds fault with the regulators, more especially those on the metered lamps. He says the flame is far too small, and wants new regulators put on—I suppose, so as to increase the consumption of gas. My experience is, if we had not the meters, we should be more troubled than we are now, because the meter shows the actual consumption and is a check upon the inspector.

Mr. R. **Godfrey**: Considerable difficulty arises, in the case quoted, from the fact of the joint partnership between the gas company and the local authority. I would suggest a plan by which that can be avoided—the one adopted by Birmingham. There the local authorities find the meters and the gas department maintain the regulators. If the gas department find the regulator bad they put up a new one. Thus, I think, should be the bargain made in every case, and then there would be a mutual check; but if the meters and regulators both belong to the same body there is sure to be some dissatisfaction. I have about fifty-seven meters in my district, and I wish I could check them in an afternoon. It takes two horses and a man a day to go round and check the regulators and the meters.

Mr. T. DE COURCY MEADE: I carefully considered this subject four years ago. I then found that there were many districts in London in favour of the meter system, and many in favour of the regulator system; but on going into the question I found there were different kinds of regulators in use. Mr. Strachan has not given us a description of the regulators he used. Some, I know, do not last nearly so long as others without attention. Some of the old-fashioned ones, with leather diaphragms, used to last a fair average time in fine weather, but wet weather affected them. The new metal, or steatite, regulators last longer, but the naphthaline from the gas affects the metal, and also the steatite, though not to so great an extent. There is a very simple check in the portable photometer. If you suspect that you are not getting the full quantity of light from the gas supplied to the public lamps, you can very easily test it in this way; but, as a rule, I find that we get more gas than we pay for, and we save the cost of meters. I think the regulator system, as practised in some districts in London, is very satisfactory. I would name, for example, Islington. St. Pancras has the meter system, but any one driving through this district will find one street very well lighted, whilst the next, perhaps, is in a state of semi-darkness.

Mr. W. WEAVER: I think Mr. Strachan is to be commended for the very careful experiments he has made with the lamps in Chelsea. Still, I think it would be somewhat premature to adopt his system of regulators to the lamps in preference to the meter system, until his experiments have been extended over a considerable period. When we adopted the average meter system in Kensington, at the beginning of 1877, I know we had a good deal of difficulty with the gas company to get them to agree as to the position of the meters, and to cut down the proportion of metred lamps as low as possible. When we at last succeeded in getting the system introduced into Kensington, I rather flattered myself that I had done a good thing for the parish; and our next annual report showed a considerable saving compared with the preceding year. From our last year's report I find that we had 4200 lamps, and the average cost, including cleaning and all incidental expenses, was 2*l.* 19*s.* 5½*d.* per lamp. This was considerably less than we used to pay the gas company previously for an inferior light. One great difficulty I see in practically carrying out Mr. Strachan's suggestion of depending solely on regulators attached to the burners, would be the difficulty of getting accurately the hours the lamps were burning. In a large district, where ten or eleven gangs of lamplighters were started at irregular times—from a fog coming on, or from other causes—there would be great difficulty in getting a proper record of the hours the lamps were lighted. If they only got done out of half-an-hour for some 4000 lamps it would very soon amount to a decimal of a halfpenny.

Mr. **Hepworth** (Carlisle Gasworks): I assure you I feel it a great pleasure to be here, but I did not expect that I should be called upon to speak on the question now before the meeting. I have listened to Mr. Strachan's paper with very great pleasure, and for the most part concur in the conclusions at which he has arrived. I think the series of experiments Mr. Strachan has made shows that you can get good regulators if you choose to do so. I have under my care between 1400 and 1500 lamps, and I have not found it necessary to adopt the average meter system; because the Corporation own both the gasworks and the lamps. I have made very careful experiments with regulators for the last fifteen or twenty years, and I thoroughly agree with Mr. Strachan, that there is no necessity to adopt the average meter system. Where you have a gas company who give irregular pressure and no regulators are employed, then the average meter system is a great advantage, and as the last speaker has pointed out, where you have to begin lighting at irregular hours, the average meter system becomes valuable. But if the hours of lighting are regular, and the pressure pretty uniform, you may depend on having as good results as Mr. Strachan has mentioned in his paper, from the use of the regulator alone, as you can secure by the use of meters and regulators combined. This has passed the stage of experiment, for there are gentlemen in this room who have used regulators of some kind for the last twenty years. Therefore I do not think it necessary to wait for further experiments in corroboration of Mr. Strachan's conclusions, because we have had them during the last twenty years.

Mr. **Strachan**: The first point to which I will reply is as to the cost of the average meter system. I do not think any person will quarrel with my estimate of 7*l.* 10*s.* for a meter fixed in a box. If 7*l.* 10*s.* is a fair estimate for a meter, then 200 meters come to 1500*l.* The item most quarrelled with was that 150*l.* I am willing to allow 20 years as the life of a gas meter, which I presume no one will say is inadequate. Depreciation we will put at 5 per cent., and you cannot borrow money on the London market at less than 3½ per cent. These two charges amount to 8½ per cent., and you cannot put the repairs at less than 1½ per cent., making the total charges 10 per cent. Well, 10 per cent. on the 1500*l.* for meters is 150*l.* a year. 5 per cent. for depreciation, 3½ per cent. for interest, and 1½ per cent. for repairs would be, I contend, a fair and proper estimate. Mr. Lemon said he did not pay for the time of his assistant who checked the meters; but his services have to be paid for. You may not miss a meal, but it costs money for all that, and it is no answer to the argument to say we have it in the house, and it does not cost us anything. It does cost you something, although you may not feel it. Therefore I say that my estimate of 9·9*d.* was a fair and proper one. I am prepared to follow Mr. Lemon's opinion in many matters, but when I have eleven years' experience pointing altogether in a different direction, I hope you will not consider I am showing any disrespect for his opinion, when I decline to follow it in this matter. At Kensington the average meter system has given good results. During the eleven years they have been used, they have burned on the average in each lamp 4·503 cubic feet, with the regulator burners set at 4·5, and that is as near as one can come to in this world. If then eleven years' experience shows that regulator gas burners are as accurate as meters, of what use are the meters? That has not been answered, and no amount of opinion will affect that question. Mr. Weaver, my friend and neighbour, says, "How many years' experience have you had of this system?" I have never used any other system in Chelsea, and have depended entirely on the regulator burners. Mr. Weaver says, "What do you do in case of fog, when you have to light up earlier?" Well, we leave the gas company to find out that the lamps are lit up. When they do find it out, we have a very simple way of settling the matter, and it is very easily done. We have a lighting inspector, and he meets the lamplighters at a particular point, at a certain hour every night, which varies as the period of the year varies. He starts the men to their respective districts, and they have to report themselves back to him at a certain time. We know the lamps are lighted, because if each man does not report himself within the prescribed time, he gets into trouble. If the men start earlier on these rounds, we simply report the fact to the gas company that the men started so much earlier. I think we save the cost of the average meter system, and get more gas. Mr. Eachus says that it is worth while to incur a small expenditure to check a larger one. Experience shows that regulator burners do this as correctly as meters, and therefore you ought to have as much confidence in burners. As to having used 4, 5, and 6-feet regulator burners for the different experiments, it was just by accident that the maker had no more four-feet burners in stock. It does not vary with the cubic feet per hour, that does not affect it at all.

WATER SUPPLY.

By W. SANTO CRIMP, Assoc. M. Inst. C.E., F.G.S.

Of all the duties of the Town Surveyor, that of providing the community with a sufficient supply of pure water, is, probably, the most important, since health, happiness, and life itself depend to a great extent on the purity of the public water supply.

Pure water is an absolute necessity for the domestic uses of mankind; where persons congregate together in large towns, the problem of its supply is frequently one difficult of solution.

The quantity necessary for the various uses of the community is the first aspect of the question, and here we cannot do better than examine the returns affecting this great Metropolis, since the users of water in so large a community are of such varied character, that we may deduce therefrom a very fair average.

During the seven years 1880–7,* the average volume of water supplied per head per day in London was 31·32 gallons; the maximum rate of supply was 34·53 gallons, and the minimum 28·12 gallons. The maximum rate of supply is in the months of July and August, whilst the minimum is during December, January, February, and March. It will be observed that the mean rate of supply is exceeded by 10 per cent.—very nearly—during the summer, whilst in winter the consumption is about 10 per cent. below the mean; to be accurate, the range between the minimum and maximum is as nearly as possible 22 per cent.

We may next consider the purposes for which water is needed; and here it should be mentioned, that whilst an ample supply should be furnished, waste should be strenuously guarded against, since waste of water is waste of money, and indeed, during periods of prolonged drought, serious inconvenience, if not actual disaster, may result from a want of care in husbanding the stores of water available for the use of man. Means of detecting waste will be considered later, but the following table will show what has already been done by the adoption of the very excellent system devised by Mr. Deacon:—

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* Annual Reports of the Local Government Board.

TABLE OF WATER SUPPLY TO TOWNS.

Town.	Daily Supply before Waste was stopped, in Gallons per Head.	Present Supply in Gallons per Head.
Atherton	no record	11·4
Abergavenny	42·0	17·2
Bath	36·0	12·0
Birkenhead	24·0	17·7
Bolton	32·5	14·8
Bradford	22·5	14·3
Carlisle	42·5	24·0
Chelsea Water Company	40·0	16·0
Chorley	not known	7·8
Chester	31·0	13·5
Clevedon	40·0	20·0
Exeter	60·0	25·0
East London Water Company	26·5	16·1
Gloucester	32·0	17·0
Glasgow	51·3	40·8
Hereford	53·0	24·0
Hertford	38·5	17·5
	intermittent	constant
Lambeth Water Company	35·0	24·8
	intermittent	constant
Lancaster	51·3	34·3
Liverpool	33·5	17·0
	constant	exclusive of trade
New River Water Company	26·4	14·0
Norwich	40·0	15·0
Portsmouth	35·0	18·3
Southampton	60·0	39·5
Southwark and Vauxhall Water Company	38·0 intermittent	22·2 constant
Stamford	24·0	18·0
Salisbury	50·0	31·6
Averages	38·6	20·13

Having deduced from the table the fact, that with good fittings the average water supply of a large number of towns is at the rate of 20 gallons per head per day—omitting the fraction—we may inquire into the uses to which the water is applied.

In Parkes' 'Practical Hygiene,' 1883, the following is the estimate of the amount of water used per diem by a man of the "middle class":—

Cooking purposes	·75 gallons.	Domestic purposes.
Fluids as drink	·33 "	
Ablution, including sponge-bath	5·00 "	
Utensil- and house-cleaning	3·00 "	
Laundry	3·00 "	
Total	12·08 gallons.	

Water-closets.

The quantity of water used in water-closets depends on the frequency with which they are used, and on the kind of fittings. It may, however, be taken that 5 gallons per head per day will be sufficient for this purpose.

Dr. de Chaumont states, in the work referred to, that 25 gallons per head should be allowed daily for all domestic purposes, one reason being that the "waste," estimated at 3 gallons per head per day, would assist in keeping the sewers clean.

Animals and trade.

Horses and cows require about 6 gallons per head per day; and 5 gallons per head per day are said to be necessary for trade and public purposes; but in the case of manufactories using exceptional amounts of water, the quantity required must be estimated for separately. Hospitals also require larger amounts than the normal rate of supply. In London 18 per cent. of the 1879 rate of 32·7 gallons per head per day was allowed for trade purposes; this is at the rate of 6 gallons per head per diem, very nearly.

The table shows, however, that the proportion of waste is much higher than had been anticipated; and in towns of the ordinary class, 14 gallons only are used by each person daily, and allowing 6 gallons for trade purposes, the total is 20 gallons per head per day.

Monthly consumption not regular.

The consumption of water is not, as before pointed out, constant month by month. In the summer there is an increased demand on the mains for water for laying the dust on the streets, and for sewer-flushing and other purposes.

Daily draught on mains.

Then the water is not drawn from the mains at a regular rate throughout the whole 24 hours; during some of the night hours very little water is required, whilst in the forenoon water is being constantly drawn for domestic and other purposes, and according to Dr. Pole,* the consumption then rises to double the mean daily supply.

Mains.

In laying down mains, therefore, not only must increase of population be provided for, but the main must be sufficient in size to admit of the maximum daily demand being satisfied. Disastrous results might follow on the breaking out of a fire during the hours of maximum draught, should the pressure not be maintained.

Capacity of mains.

If the mean yearly consumption be 20 gallons per head, 10 per cent. must be added for the summer requirements, making 22 gallons per head; then that volume will be doubled during the hours of greatest consumption, hence the main must be capable of delivering 44 gallons per head, if the generally approved system of "constant supply" be adopted. Provision for increase of population must also be made, as may be necessary.

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* Pole on Water Supply, Inst. C.E., 1884–5.

Objections to intermittent supply.

The chief objections urged against the supply of water being "intermittent," are that the cisterns and other receptacles which are necessary for storing a day's supply, often become foul by reason of their position in the roof, under floors, or elsewhere, where they are difficult of access. Dr. Letheby stated, in giving evidence before the Rivers Pollution Commissioners,* that the water drawn direct from the mains would be cooler and less liable to pollution, since the "receptacles of the poorer people were often close to privies, dirty cellars, &c."

Objections to constant supply.

The chief objections to a constant supply were—in the Report referred to—(1) the leakage from fittings; (2) insufficiency of strength; (3) the greater consumption during the forenoon, rendering larger mains a necessity, and larger pumps, where a service reservoir was not employed; (4) the greater draught in the forenoon reducing the pressure in the mains at the higher levels; (5) an accident to, or repair of, a main, cutting off the house supply altogether, there being no house cisterns to keep up the supply.

Good fittings indispensable.

The commissioners considered that a sufficient answer to these anticipated difficulties existed in the fact that at that date 72 towns had adopted the constant-supply system. Indeed, the better kind of fittings used with constant supplies had led to a great saving of water. The average supply per house per day of the 72 tabulated towns † was 134·4 gallons, or about 24·4 gallons per head, whilst in the case of 24 towns—including London—supplied intermittently, 204 gallons were supplied to each house per day, or about 37 gallons per head.

Sources of supply.

We may now briefly consider the general sources of water supply. The primary source is rain, but it is collected for use in a variety of ways.

Roofs and paved surfaces.

1. From roofs and paved surfaces, rain is collected and stored in butts, cisterns, tanks, &c. This system is frequently adopted in villages, and in isolated buildings of various kinds where a supply from mains is not procurable. The water should be filtered, in order to remove the filth deposited on the collecting areas by birds and by the atmosphere. The author has seen cases on the chalk hills, where areas quite close to the ground have been slated, in order to provide a large collecting surface. The water thus pro-

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* Sixth Report, p. 228, 1874.

† Ibid., p. 232, 1874.

vided is quite soft, and may dissolve metallic impurities from its storage tank, should it be constructed of lead.

Rain-water tanks.

It may be mentioned, incidentally, that if the provision of large rain-water cisterns were insisted upon in the case of town houses, the troubles of dealing with heavy rainfalls might be much lessened. The soft water collected would be of much service for domestic uses, whilst the cisterns would act as regulators of the storm water.

Gathering ground and storage reservoirs.

2. When the rain falling on impervious surfaces is collected in storage reservoirs, the area on which it falls is termed a "gathering ground." A great number of examples may be found in nearly every country; our Welsh hills, and the elevated portions of the North of England and of Scotland, are exceptionally well suited for this mode of procuring water supplies, the rainfall being high, the strata over very large areas being impermeable—or nearly so—and sources of contamination, other than vegetable, being nearly absent. The water yielded by these gathering grounds is, however, frequently of a peaty colour, owing to the colouring matters in the dead plants being dissolved out, just as ordinary water may be discoloured by placing in it a wisp of hay. The rains following prolonged droughts are specially affected, and means are sometimes adopted for the separation of highly-coloured streams from the general supply. The vegetable organic matter is lessened by exposure to atmospheric oxidation in lakes and reservoirs, and the larger these are, therefore, in proportion to the water drawn from them, the purer will the water become.

Discoloration of soft water.

Action of soft water on lead services.

It has sometimes occurred that the soft waters collected in lakes and reservoirs possess the property of dissolving lead from the services by which it is taken from the mains into the houses. Loch Katrine water is especially active in this respect. The question was very fully examined by the Rivers Pollution Commissioners,* and they arrived at the conclusion that in order to secure immunity from attacks upon lead, it is necessary that these soft waters should contain a certain proportion of phosphate of lime. It is also stated in the Report that new untarnished lead pipes are acted upon much more violently than those which have been in use for some time, a protecting film soon being deposited upon those surfaces in contact with the water.

Pipes lined with tin in such a manner that the tin does not form an alloy with the lead, but remains pure, are not affected by the attacks of soft water.

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* Sixth Report, 1874, p. 224.

Action of shallow well water upon lead services, &c.

In the case of shallow well waters, the action upon lead and galvanised iron is in some instances of a continuous and violent kind. Such a case was that of the Oakfield well at Wimbledon, mentioned in the Report referred to. An analysis of the water showed it to be deficient in carbonic acid, and wholly free from phosphates.

To return to the "gathering ground"; the water falling as rain soon forms little streams, these unite as their courses tend to the lower levels, until low down the valley, their aggregation is seen in the roaring torrent, or the placidly flowing river.

Impounding reservoir.

At what point in the valley should the water be intercepted? If there is a natural lake of sufficient size, its waters may be abstracted, or its area may be added to by means of an embankment or wall, should that course be necessary. If no lake exists, a natural one must be formed by means of a wall or an embankment, but in selecting the point for its construction an accurate knowledge of the geological strata of the immediate locality must be ascertained. If the strata are of a rocky nature, with fissures, it may be necessary to carry the retaining medium to a very considerable depth, in order to prevent the escape of the water, and the possible destruction of the embankment. The bottom of the reservoir must also be made watertight so far as is practicable, and very great care must be taken in the design of the outlet arrangements. In short, as the most disastrous results to life and property might follow the failure of a reservoir dam—as at Sheffield in 1864—it is impossible to exercise too much care in all the details affecting its design and construction.

Embanking.

Possibly the greatest difficulty in connection with proposed waterworks of the kinds under discussion is that of ascertaining the volume of water that will be yielded by a given gathering ground, or watershed. If the surface is largely composed of steep, rocky impervious formations, the water will be rapidly delivered into the valleys, with the retention by the surfaces of a comparatively small quantity. Should the area, on the other hand, be of a flat character, with much vegetation, large quantities of water will be retained by the plants, particularly in the case of thick deposits of peat, the water remaining in the pores of which, and on the various surfaces, evaporates on the cessation of the wet weather. Some of the water might also be lost by percolation, should porous strata be present; in the case of great chalk formations it is rarely that any water flows off the surface.

Dr. Dalton, who has given many years of study to the question of the volumes of water available for water-supply proportionately to the rainfall of this country, states that the amount is about one-third of the total rainfall. At Loch Katrine in 1854,* the rainfall for the year was 103 inches, four-fifths of which were discharged by the loch, one-fifth being lost by evaporation, percolation, and absorption.

It will, however, be much more correct to assume that the losses through the various causes will be certain in amount yearly, than to calculate that it will be proportional to the rainfall. Dr. Pole † estimated that the losses would vary from 12 to 18 inches in depth per annum, accordingly as the gathering ground might be of steep impermeable rock, or of flatter permeable formations.

In calculating the size necessary for a storage reservoir, the mean annual rainfall of the district in which it is to be situated must be ascertained, and as the yearly fluctuations of the rainfall are very considerable, provision must be made for impounding a supply sufficient for the wants of the community during periods of drought.

Rainfall.

Mr. Symonds ‡ has been able to deduce the following rules from an extended study of the rainfall of this country:—

(1) The wettest year will have a rainfall nearly half as much again as the mean.

(2) The driest year will have one-third less than the mean.

(3) The driest two consecutive years will each have one-quarter less than the mean.

(4) The driest three consecutive years will each have one-fifth less than the mean.

(5) At wet stations the extremes of both wetness and of dryness are less marked than at dry ones.

Storage.

Dr. Pole § stated that in the judgment of experienced practitioners, 150 days' storage should be provided in wet districts and 200 days in dry. In very wet districts the storage to be provided might be less.

Compensation water.

As the stream to be impounded probably supplies power to mills lower down the valley, compensation water must be provided to take the place of that to be abstracted. The reservoir is therefore made sufficiently large to store the flood water, and this is liberated by means of suitable appliances so as to equalise the flow of the stream. In manufacturing districts, one-third of the total quantity impounded is assumed to be necessary as compensation water; that is, 50 per cent. must be added to the town supply in calculating the size of the storage reservoir.

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* Evans on Physiography, Inst. C.E., 1884–5.
† Pole on Water Supply, Inst. C.E., 1884–5.
‡ Symonds' 'British Rainfall,' 1883, p. 32.
§ Pole on Water Supply, Inst. C.E., 1884–5.

River supplies.

3. In some cases, notably in that of the London water supply, water is taken direct from a river, and, after being suitably treated, is pumped into reservoirs and mains for supply to the people.

Objections have been frequently urged to the abstraction of raw river water for domestic supplies, in consequence of the fouling of the streams by sewage and by other matters. The surveyor, therefore, in examining into such a source of supply, should ascertain whether or not the stream is liable to pollution. As diphtheria and typhoid fever are most readily communicated by means of water, every endeavour should be made to obtain a supply free from suspicion.

Five of the great London water-supply companies take their supplies direct from the Thames, and, with the great improvements in the construction of filters during recent years, experience shows that such water may be rendered wholesome and fit for domestic purposes. Wimbledon is supplied by two of the companies, and for years the death-rate has averaged about 12 per 1000; there being no wide fluctuations such as are indicative of defective sanitary conditions.

River waters are frequently rendered turbid by floods, and, if possible, provision should be made for storing sufficient water to preclude the necessity of taking the river water when thus fouled.

Filtering river water.

The great filters of the London water companies are built up in the following manner:—

Coarse gravel, with drain-pipes at intervals	1 foot.
Medium gravel	1 „
Fine gravel	1 „
Fine sand	1·25 to 2 feet.

The top layer—fine sand—is alone capable of arresting micro-organisms. The rate of filtration, to be effective,* should not exceed 2½ gallons per square foot of filter per hour, or 540 gallons per square yard per twenty-four hours. Subsidence of the suspended matters is desirable before the water is admitted to the filters, in order to prevent the pores of the filters being choked. The filters must be kept in a cleanly condition, the top inch or so of sand being periodically removed and replaced by clean sand. Dr. E. Frankland has shown by his biological experiments during 1886,* that the average reduction in the micro-organisms present in the unfiltered Thames and Lea waters, before delivery to the consumer, amounted to 97·6 and 96·5 per cent. respectively.

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* Fifteenth Annual Report, L.G.B., 1885–6.

As the London water supply for the year 1886 averaged 30·47 gallons per head per day, each square foot of filter served for the filtration of the water required for two persons, or one acre would be necessary for 87,000 persons; as, however, portions of the filtering area are always undergoing cleaning operations, the area of filter actually provided is necessarily in excess of the estimated amount.

Well water.

4. When water has to be drawn from wells sunk in porous strata, the problem of the quantity available becomes one difficult of solution. Then, such water, in its passage to the pumping station, may pass under towns, or other sources of pollution, and thus become contaminated by means of leaky sewers, or of cesspools, or otherwise.

Hydro-geological surveys.

During late years much information has been gained with regard to the movements of underground waters. The author was for a considerable period engaged in this question, during the years 1879–1883. The watershed particularly examined was that of the Wandle. All the wells in the area were found, and their mouths were reduced to Ordnance Datum; then at intervals of about a month, the depth to the surface of the water in every well was measured within a period of a few days, so that the exact position of the water-line, or surface of the underground water, was known at certain dates; by carefully examining the gradients found to exist, it was found possible to ascertain the direction in which the water was moving, although its surface was, in places, hundreds of feet below that of the ground.

When, therefore, a supply from deep wells is contemplated, such a survey should be made, for not only will the surveyor be enabled to predict the quantity that will be available, but he will also be enabled to ascertain whether or not the supply is liable to contamination. Of course, when porous formations are overlaid by considerable thicknesses of impermeable ones, the question is one that must be examined by the light of geological knowledge.

Depression by pumping.

When wells are sunk and pumping is resorted to, the surface of the water in the well will be lowered proportionately to the pumping power employed and to the amount of the supply. If wells in the immediate neighbourhood be observed, it will be found that the surface of the water in them will be lowered with that of the main well, should the wells be sunk in the same pervious formations. It will also be found that the surface gradient of the water within the area affected will slope in all directions towards the main well, and it may be proved by means of the lithia test that even if the main well be lined with watertight iron cylinders to a considerable depth, the surface water will flow towards and into the well. The depression produced by pumping is termed the "cone of depression," and it should be a *sine quâ non* of a water-supply works that there should be no sources of pollution within the area of the "cone of depression."

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* Sixteenth Annual Report, L.G.B., 1886–7.

Hard water.

It must be remembered that water procured from wells is simply that portion of the rainfall which passes downwards through porous strata, and is stored in the crevices and pores of the various formations suitable for its reception. When the strata passed through by the water are of limestone, a portion is dissolved, and waters derived from these formations are said to be hard, that is, they contain various salts in solution, in consequence of which they have a harsh feeling when used for personal ablution, and much soap is destroyed in artificially softening them.

The hardness of water is expressed in degrees,* and 1 lb. of carbonate of lime, or its equivalent of other hardening salts, in 100,000 lb. or 10,000 gallons of water is equal to 1 degree of hardness, and 12 lb. of best hard soap would be destroyed in 10,000 gallons of water, when used for washing, by each pound of hardening salt.

Water is said to be "temporarily" hard, or "permanently," hard, accordingly as the water may contain the bicarbonates of lime and magnesia, or the sulphates of the same minerals. The term "temporary" hardness is used because the water so hardened may be softened by boiling, the salts being decomposed into free carbonic acid and the carbonates of lime and magnesia, which latter are sparingly soluble. When water cannot be softened in this way—as when hardened by the sulphates of lime or magnesia—it is said to be "permanently" hard.

The following formations yield waters which are, as a rule, either hard or soft, as tabulated: †—

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* Sixth Report, R.P.C., 1874.

† Ibid.

Soft Water.	Hard Water.
Igneous.	Silurian (calcareous).
Metamorphic.	Devonian (calcareous).
Cambrian.	Mountain limestone.
Silurian (non-calcareous).	Coal measure (calcareous).
Devonian (non-calcareous).	New red sandstone.
Millstone grit.	Conglomerate sandstone.
Coal measures (non-calcareous).	Lias.
Lower greensand.	Oolites.
London and Oxford clay.	Upper greensand.
Bagshot beds.	Chalk.
Gravels (non-calcareous).	

When the rain falling upon limestone surfaces does not penetrate the rock, but is discharged into streams and reservoirs, it differs but little in composition from that yielded by non-calcareous surfaces; but when the formation is uniformly porous, the water, passing deep down through the mass of the rock, becomes loaded with mineral matters and hardened, hence the nature of deep-well waters procured from the chalk, oolitic, new red, and other formations. In passing slowly downwards, the organic matters derived from vegetation become oxidised and changed into harmless mineral compounds, leaving the water very palatable and wholesome, excepting when unduly charged with saline matter.

Softening water by distillation.

All hard waters may be softened by distillation, as the salts will not pass over with the vapour; but water so softened has a flat, unpalatable taste, owing principally to the absence of carbonic acid gas, and to the presence of volatile organic matter. The remedy is to filter the distilled water through animal charcoal, but the process is a costly one, and is principally employed on ships, where the storage tanks, necessary for supplies of fresh water required during long passages, are inadmissible; in such cases sea-water is frequently distilled, and converted into potable water.

Softening water by means of soap and soda.

The fact that hard water may be softened by means of soap has already been mentioned. Soda is another substance frequently used for this purpose, and it is both cheaper and more powerful in its action than soap. One lb. of soda is equal in effect to 4¼ lb. of best soap, whilst its price is about one-fourth that of soap; hence soda is extensively used in laundries.

Softening water by boiling.

Water is commonly softened by boiling, and the separation of the hardening salts may be effected by constant ebullition for half an hour. The salts which are present as bicarbonates are decomposed into insoluble, or sparingly soluble, carbonates of lime, magnesia, or iron; carbonic acid gas being expelled by the process of boiling. Water so softened is frequently muddy, in consequence of the dissolved solids becoming changed into visible suspended matters. In order to raise the temperature of 1000 gallons of water to the boiling-point and to maintain it in that condition for half an hour, 2½ cwt. of coal would be required. This method of softening water is therefore an expensive one.

Softening water by the "Clark" process.

The excellent process of softening water by means of lime, as devised by Dr. Clark, is the cheapest yet known, and is in extensive operation at many waterworks situated on the great limestone formations. The process, however, is only applicable to those waters which owe their hardness to the carbonates of lime and magnesia; that is, to waters which are said to be temporarily hard. The chemical action is a simple one, the chalk or other hardening salt exists in water as bi-carbonate, which is soluble; lime is added to the water to be softened, and combining with a portion of the free carbonic acid, forms carbonate of lime; the bi-carbonate present in the water is decomposed—into carbonate also—by the withdrawal of a portion of the carbonic acid, and the water so treated becomes turbid from the production of nearly insoluble salts; settling tanks are provided in which the suspended solids may subside, and the softened water, as then distributed for use, contains about 4 degrees of "hardness" only. Mechanical filters, as in the "Porter-Clark" process, have more recently been introduced for the purpose of separating the suspended solids produced, thus rendering unnecessary the settling tanks at first used. Chalk water with 17½ degrees of hardness would contain 1 lb. of chalk in 400 gallons; in order to precipitate the chalk, 9 ounces of lime, dissolved in 40 gallons of water, would be necessary; the lime would combine with the free carbonic acid to produce 1 lb. of chalk also, and the precipitate would be 2 lb. of chalk, assuming the chemical action to be complete.

According to the Sixth Report before referred to:—

	£	s.	d.
1 cwt. of lime, costing	0	0	8
4¾ cwt. of soda	2	17	9
20¼ cwt. of soap	47	1	8

would each produce the same softening effect on water "temporarily" hard; obviously, therefore, it is to the great benefit of the community that such waters should be softened by means of lime at the works.

Springs.

5. Occasionally water-supplies are procured by intercepting springs, thrown out at the junction of impermeable formations

with those of a porous nature. In such cases the geology of the district must be carefully studied, in order to ascertain where the water is derived from, and whether or not an efficient supply can be depended upon during periods of drought. The volume yielded to the streams should be ascertained by means of careful gaugings, extending over dry periods, when the springs are at the minimum.

Artesian wells.

6. In many localities, and especially in the Thames and Wandle valleys, water is procured in moderate quantities by means of borings carried through the London clay, and Woolwich and Reading beds, into the porous Thanet sands or into the chalk. At Wimbledon the water so procured rises to a height of about 56 feet above O. D., so that a large number of wells, which have been bored in parts of the locality lying at the lower level, overflow constantly, on the impervious strata overlying the water-bearing formations being pierced. It is highly probable that the water derived from these borings passes under the clays in its northward course from the Surrey hills, in the chalk of which it is stored at levels of 100 feet and upwards above O. D.

Internal distribution.

The question of internal distribution is one which need not be considered at very great length. The sizes of the various subsidiary mains will be regulated by the probable demand. In the author's district, the smallest branch mains used are 3 inches in diameter, that size being sufficient for the greatest demand likely to arise in the case of a fire breaking out in a side street. The mains should be jointed with lead only, if turned and bored joints are not used; the use of tow or gaskin has led to the pollution of the water supply; this was notably the case in the main laid by the Southwark and Vauxhall Water Company in 1869, and referred to in the Sixth Report of the Rivers Pollution Commission.

The mains must be furnished with the necessary valves, hydrants, and means for washing out.

Pumping.

Pumping machinery should be provided in duplicate, in order to provide for a possible breakdown, should it be necessary to pump the required water.

Service reservoirs.

The service reservoir is a necessary adjunct of a water supply scheme, in order to regulate the fluctuations of the demand, and to contain a store for sudden emergencies, such as the bursting of the supply-main from the pumping station or some distant storage reservoir, or the breaking out of a great fire. Such reservoirs should contain one to one and a half day's supply,* and should be covered in order to exclude filth, and to diminish the risks of pollution. In hilly districts, and in those towns with large populations, two or more service reservoirs may be necessary and even desirable.

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* Pole on Water Supply.

Prevention of waste.

The prevention of waste is an important matter, and may be readily accomplished by the excellent method devised by Mr. Deacon. Briefly, the plan consists in dividing the area supplied into a number of small districts, the water-supply to each of which is made to pass through one of Deacon's self-recording meters, on the diagrams of which the amount of water passing is faithfully recorded hour by hour. The period from about midnight to 5 a.m. is that in which waste may be detected, since the demand on the mains for domestic purposes is then at a minimum. The localisation of leakage, from either branch mains, or from domestic fittings, is a matter of detail, necessitating night inspections, and isolation of houses and of branch mains. In a report by Mr. Binnie, M. Inst. C.E., on the Bradford water-supply, it is stated that in a district containing 81,038 persons and 40,463 taps, the consumption of water had been reduced from 22·47 gallons to 14·35 gallons per head, merely by suppressing waste.

House fittings.

When water is provided for the community and distributed on the constant supply system, it is of great importance that each house should be provided with fittings of the best quality and type, and also that these should be arranged so as to prevent contamination of the main supply. The regulations made under the Metropolis Water Act, 1871, with regard to the prevention of waste and misuse of water, are so valuable from a sanitary point of view, that the author hopes their inclusion with this paper may be of service to members of the Association.

APPENDIX.

Regulations made under the Metropolis Water Act, 1871.

Place of communication pipe.

1. No "communication pipe" for the conveyance of water from the waterworks of the company into any premises shall hereafter be laid until after the point or place into which such "communication pipe" is proposed to be brought into such premises shall have had the approval of the company.

Weight of lead pipes.

2. No lead pipe shall hereafter be laid or fixed in or about any premises for the conveyance of or in connection with the water supplied by the company (except when and as otherwise authorised by these regulations, or by the company), unless the same shall be of equal thickness throughout, and of at least the weight following, that is to say:—

Internal Diameter of Pipe in Inches.	Weight of Pipe in lb. per lineal Yard.
⅜-inch diameter.	5 lb. per lineal yard.
½ " "	6 " "
⅝ " "	7½ " "
¾ " "	9 " "
1 " "	12 " "
1¼ " "	16 " "

Interior pipes.

3. Every pipe hereafter laid or fixed in the interior of any dwelling-house for the conveyance of, or in connection with, the water of the company, must, unless with the consent of the company, if in contact with the ground, be of lead, but may otherwise be of lead, copper, or wrought iron, at the option of the consumer.

Not more than one communication pipe to each house.

4. No house shall, unless with the permission of the company in writing, be hereafter fitted with more than one "communication pipe."

Every house, with certain exceptions, to have its own communication pipe.

5. Every house supplied with water by the company (except in cases of stand pipes) shall have its own separate "communication pipe." Provided that, as far as is consistent with the special acts of the company, in the case of a group or block of houses, the water-rates of which are paid by one owner, the said owner may, at his option, have one sufficient "communication pipe" for such group or block.

No house to have connection with fittings of adjoining house.

6. No house supplied with water by the company shall have any connection with the pipes or other fittings of any other premises, except in the case of groups or blocks of houses referred to in the preceding regulation.

Connection to be by ferrule or stop-cock.

7. The connection of every "communication pipe" with any pipe of the company shall hereafter be made by means of a sound and suitable brass screwed ferrule or stop-cock with union, and such ferrule or stop-cock shall be so made as to have a clear area of waterway equal to that of a half-inch pipe. The connection of every "communication pipe" with the pipes of the company shall be made by the company's workmen, and the company shall be paid in advance the reasonable costs and charges of and incident to the making of such connection.

Material and joints of external pipes.

8. Every "communication pipe" and every pipe external to the house and through the external walls thereof, hereafter respectively laid or fixed, in connection with the water of the company, shall be of lead, and every joint thereof shall be of the kind called a "plumbing" or wiped joint.

No pipe to be laid through drains, &c.

9. No pipe shall be used for the conveyance of, or in connection with, water supplied by the company, which is laid or fixed through, in, or into any drain, ashpit, sink, or manure hole, or through, in, or into any place where the water conveyed through such pipe may be liable to become fouled, except where such drain, ashpit, sink, or manure hole, or other such place, shall be in the unavoidable course of such pipe, and then in every case such pipe shall be passed through an exterior cast-iron pipe or jacket of sufficient length and strength, and of such construction as to afford due protection to the water pipe.

Depth of pipes under ground.

10. Every pipe hereafter laid for the conveyance of, or in connection with, water supplied by the company, shall, when laid in open ground, be laid at least two feet six inches below the surface, and shall in every exposed situation be properly protected against the effects of frost.

No connection with rain-water receptacle.

11. No pipe for the conveyance of, or in connection with, water supplied by the company, shall communicate with any cistern, butt, or other receptacle used or intended to be used for rain water.

Stop-valve.

12. Every "communication pipe" for the conveyance of water to be supplied by the company into any premises shall have at or near its point of entrance into such premises, and if desired by the consumer within such premises, a sound and suitable stop-valve of the screw-down kind, with an area of waterway not less than that of a half-inch pipe, and not greater than that of the "communication pipe," the size of the valve within these limits being at the option of the consumer.

If placed in the ground such "stop valve" shall be protected by a proper cover and "guard box."

Character of cisterns and ball taps.

13. Every cistern used in connection with the water supplied by the company shall be made and at all times maintained water-tight, and be properly covered and placed in such a position that it may be inspected and cleansed. Every such existing cistern, if not already provided with an efficient "ball tap," and every such future cistern, shall be provided with a sound and suitable "ball tap" of the valve kind for the inlet of water.

Waste pipes to be removed or converted into

14. No overflow or waste-pipe other than a "warning pipe" shall be attached to any cistern supplied with water by the company, and every such overflow or waste-pipe existing at the time when these regulations come into

warning pipes.

operation shall be removed, or at the option of the consumer shall be converted into an efficient "warning pipe," within two calendar months next after the company shall have given to the occupier of, or left at the premises in which such cistern is situate, a notice in writing requiring such alteration to be made.

Arrangement of warning pipes.

15. Every "warning pipe" shall be placed in such a situation as will admit of the discharge of the water from such "warning pipe" being readily ascertained by the officers of the company. And the position of such "warning pipe" shall not be changed without previous notice to and approval by the company.

Buried cisterns prohibited.

16. No cistern buried or excavated in the ground shall be used for the storage or reception of water supplied by the company, unless the use of such cistern shall be allowed in writing by the company.

Butts prohibited.

17. No wooden receptacle without a proper metallic lining shall be hereafter brought into use for the storage of any water supplied by the company.

Ordinary draw-tap.

18. No draw-tap shall in future be fixed unless the same shall be sound and suitable, and of the "screw down" kind.

Draw-taps in connection with stand pipes.

19. Every draw-tap in connection with any "stand pipe" or other apparatus outside any dwelling-house in a court or other public place, to supply any group or number of such dwelling-houses, shall be sound and suitable and of the "waste preventer" kind, and be protected as far as possible from injury by frost, theft, or mischief.

Boilers, water-closets, and urinals to have cisterns.

20. Every boiler, urinal, and water-closet, in which water supplied by the company is used (other than water-closets in which hand flushing is employed), shall, within three months after these regulations come into operation, be served only through a cistern or service-box and without a stool cock, and there shall be no direct communication from the pipes of the company to any boiler, urinal, or water-closet.

Water-closet apparatus.

21. Every water-closet cistern or water-closet service-box hereafter fitted or fixed, in which water supplied by the company is to be used, shall have a sufficient "waste preventing" apparatus, so constructed as not to be capable of discharging more than two gallons of water at each flush.

Urinal cistern apparatus.

22. Every urinal cistern in which water supplied by the company is used, other than public urinal cisterns, or cisterns having attached to them a self-closing apparatus, shall have an efficient "waste-preventing" apparatus, so constructed as not to be capable of discharging more than one gallon of water at each flush.

Water-closet down pipe.

23. Every "down pipe" hereafter fixed for the discharge of water into the pan or basin of any water-closet shall have an internal diameter of not less than one inch and a quarter, and if of lead shall weigh not less than nine lb. to every lineal yard.

Pipes supplying water-closet to communicate with cistern only.

24. No pipe by which water is supplied by the company to any water-closet shall communicate with any part of such water-closet, or with any apparatus connected therewith, except the service-cistern thereof.

Bath to be without overflow pipe.

25. No bath supplied with water by the company shall have any overflow waste pipe, except it be so arranged as to act as a "warning pipe."

Bath apparatus.

26. In every bath hereafter fitted or fixed, the outlet shall be distinct from, and unconnected with, the inlet or inlets; and the inlet or inlets must be placed so that the orifice or orifices shall be above the highest water-level of the bath. The outlet of every such bath shall be provided with a perfectly water-tight plug, valve, or cock.

Alteration of fittings.

27. No alteration shall be made in any fittings in connection with the supply of water by the company without two days' previous notice in writing to the company.

Waterway of fittings.

28. Except with the written consent of the consumer, no cock, ferrule, joint, union, valve, or other fitting, in the course of any "communication pipe" shall have a waterway of less area than that of the "communication pipe," so that the waterway from the water in the district pipe, or other supply pipe of the company up to and through the stop-valve prescribed by Regulation No 12, shall not in any part be of less area than that of the "communication pipe" itself, which pipe shall not be of less than a half-inch bore in all its course.

Weight of lead pipes, having open ends.

29. All lead "warning pipes" and other lead pipes of which the ends are open, so that such pipes cannot remain charged with water, may be of the following minimum weights, that is to say:—½ inch (internal diameter), 3 lb. per yard; ¾ inch (internal diameter), 5 lb. per yard; 1 inch (internal diameter), 7 lb. per yard.

Definition of "communication pipe."

30. In these regulations the term "communication pipe" shall mean the pipe which extends from the district pipe or other supply pipe of the company up to the "stop-valve" prescribed in the Regulation No. 12.

Penalties.

31. Every person who shall wilfully violate, refuse, or neglect to comply with, or shall wilfully do or cause to be done any act, matter, or thing, in contravention of these regulations, or any part thereof, shall, for every such offence, be liable to a penalty in a sum not exceeding five pounds.

Authorised officer may act for company.

32. Where, under the foregoing regulations, any act is required or authorised to be done by the company, the same may be done on behalf of the company by an authorised officer or servant of the company, and where, under such regulations, any notice is required to be given by the company, the same shall be sufficiently authenticated if it be signed by an authorised officer or servant of the company.

Existing fittings.

33. All existing fittings which shall be sound and efficient, and are not required to be removed or altered under these regulations, shall be deemed to be "prescribed fittings" under the Metropolis Water Act, 1871.

A SHORT DESCRIPTION OF THE TELEPHONE AND STREET FIRE-ALARM COMMUNICATION IN THE DISTRICT OF HORNSEY.

By T. DE COURCY MEADE, Assoc. M. Inst. C.E., Hornsey.

The importance of connecting by telephone the depôts, fire stations, and offices of the Hornsey Local Board was recognised about three years ago, and the first contract was entered into with the General Post Office for connecting the Board's offices and the Central Fire Station by telephone. The wires were carried on ornamental poles along the public roads, the distance being about 2900 yards, and a further extension of the system was undertaken by the Post Office. The poles and overhead wires were very strongly objected to by the residents along the route; and so successfully was the opposition maintained, that the Post Office authorities were unable to obtain wayleave for the intended extension of the overhead system. Therefore the Local Board ultimately resolved (with the consent of the Post Office authorities) to remove the poles and overhead wires, and to lay down a complete system of pipes for telephonic and street fire-alarm purposes.

Pipes.

The general plan shows the arrangement of pipes as carried out. The pipes were laid by the Local Board, and were of 2-inch cast iron, with turned and bored joints, weighing 23 lb. per lineal yard, and coated with Dr. Angus Smith's composition. All pipes were carefully tested to a pressure of 130 lb. before leaving the works, and were again tested and examined on delivery at the Board's depôt. No variation in weight exceeding one per cent. was allowed. The contract for the pipes was executed by the Staveley Iron Company in a very satisfactory manner, at the rate of 4*l.* 12*s.* per ton, delivered. The total length of pipe laid is 13,948 yards.

LAYING AND JOINTING.

The pipes were laid by contract. The cost for opening ground, laying the pipes at a depth of not less than 2 feet, including red lead used in jointing and filling in, and making good surface, was 11½*d.* per yard lineal. This price did not include the relay of footway paving or the cartage from the depôt.

EXAMINATION PITS AND BOXES.

Examination pits were constructed on the line of pipes at distances of about 100 yards. The pipes were laid, as far as practicable, in straight lines between the pits, and sunk examination boxes were fixed, in most cases midway between the pits, or where a curve or bend occurred. The boxes were of cast iron, weighing 86 lb. each, and were made in two castings with turned and bored joints and india-rubber washers, as shown in Fig. 1. The cost of each box delivered complete was 10*s.* The brick pits measure in the clear, 2 feet by 1 foot 6 inches by 2 feet 3 inches deep, and were constructed of London stock bricks in cement. The pits were covered with two kinds of cover, one wholly of cast iron for the footway, as shown in Fig. 2, the other being a stronger casting, with wood-blocks for the carriage-way, as shown by Fig. 3. The brick pits, including cartage and fixing covers, cost 1*l.* 2*s.* 6*d.* each. The covers were supplied by Messrs. Smith, Patterson & Co., the footway covers costing 10*s.* 6*d.* each, and the roadway covers 16*s.* 3*d.*, delivered at Hornsey.

ELECTRICAL APPARATUS.

The electrical apparatus, batteries, wires, fittings, &c. (with the exception of the telephone instruments), were provided and fixed by Messrs. Blenheim & Co., the total cost being 519*l.* 10*s.* 6*d.* The wire used was No. 16 B.W.G. copper, of not less than 95 per cent. conductivity, insulated with guttapercha to No. 7 B.W.G., and braided and ozocerited.

TELEPHONE INSTRUMENTS.

These instruments are of the Gower-Bell type, and were purchased by the Board free of royalty, and, including the three rented from the Post Office and one from the United Telephone Company, number fourteen in all.

Switch Boards.

There are three exchange switch-boards, from which the lines branch, and by means of which any point on the system can be connected with any other point. The switch-boards are worked entirely by firemen, who are on duty both night and day. The system is maintained by two exchanges at a time. The fireman on night duty at station A cuts out the whole of the wire from that station during the daytime, and brings the exchange at B into use during the day. At night the order is reversed. This arrangement saves the services of an extra man night and day. The switch boards are made of different sizes, varying according to the number of lines to be dealt with. In each line is placed a coil of wire containing a magnetic needle (very similar to an ordinary needle telegraph). One end of the coil is connected to the line and the other to a plug. When in position the plug is placed in contact with a horizontal brass bar connected with earth. The magnetic needle is supported on a steel spindle, from which is suspended a small brass disc. One end of the needle terminates in a platinum point, which is suspended immediately over a cup containing mercury. The following is the method of signalling, viz.:—On contact being made by pressing the button of the telephone instrument of a distant station, a current of electricity is sent through the line, and hence the magnetic needle of the particular coil on the switchboard is deflected, and the platinum point dips into the mercury cup as before described. This makes the contact, and a current passes from a local battery and rings the call bell; the deflection of the needle moves the disc behind a glass panel, and indicates the particular line from which the call is received. The plug attached to a flexible insulated cord is disconnected from the horizontal bar and placed in contact with a circular brass plate, which is in connection with the local instrument. A conversation is then held by the telephones in the usual way. Should the persons signalling require to speak to any other branch line outside the switching station, they ask the person on duty at the station to connect them with the third or fourth instrument as required. This is done by placing the plugs on the insulated cord connected with the instruments in one of the single brass plates immediately under the horizontal brass bar.

The Board's telephones are worked by single wires with an earth circuit; the Post Office instruments are worked with a metallic circuit. In joining the insulated wire both skill and care are absolutely necessary, as a badly made joint might cause much inconvenience. Samples of wire marked A B and C show the mode of jointing adopted. In drawing the wires into the pipes care is also necessary. When the pipes were laid a "lead wire" of ordinary galvanised wire No. 12 B.W.G. was run through, for the purpose of drawing the insulated wires into the pipes, but when additional or new wires are required, the existing insulated wires can be used for the purpose.

FIRE ALARMS.

Fire alarms are placed in the streets in convenient positions, and are defined by special lamps with ruby glass. These posts number 23 in all, and are fairly dispersed throughout the district. Each post is fitted with a glass panel, which is left to the care of the public, and up to the present time there has been no tampering with the posts, nor has there been a single instance of wilful false alarm of fire. In this respect our system differs from that in the Metropolis, where all posts are placed under the charge of the police at "fixed points." Owing to this deviation from the Metropolitan system, the Board provided numbered keys and master keys to the post locks. By this arrangement an iron panel could be placed in the door in lieu of glass, and the numbered keys served to the residents in the neighbourhood of each post. The keys would, on opening the door of the post, be retained in the lock until released by the fireman's master key, and in this way any false alarms would be detected; but, as previously stated, no false alarms have been received, therefore the glass panels are still in use. The signalling apparatus in the street alarm post consists of a coil of insulated wire of a definite resistance. Seven or eight posts can be placed on a single wire. The coil in the first post offers a resistance of say ten units, that in the second fifteen, the third twenty, and so on through the whole series. In the post is a metal disc with a projecting knob near the centre. At the back of the metal disc is a straight brass spring with which contact is made by pulling out the knob. This rings a bell at the fire station, and the alarm is acknowledged by ringing a small gong in the post which is attached to the back of the metal disc. The knob is automatically locked when drawn out, and can only be released by the fireman's master key. By the aid of this key a private code of signals is transmitted between a fireman at the post and those at the fire station. The posts are at present worked on the open-circuit system. Every post is tested by the firemen once a week. The whole system of alarms in connection with each station is worked by a battery of four cells. At the receiving station there is an arrangement similar to that shown on Fig. 4. "A" is an ordinary galvanometer, "B" a resistance coil, and "C" a switch for introducing into the circuit different resistances, "D" is a four-cell battery, "E" the line wire, "F" interior of post, and "G" is the resistance coil in the post. The whole arrangement is exceedingly simple. On an alarm being given at any post by pulling the knob as before described, contact is made, and an electric current passes from the battery through the galvanometer, line wire, and resistance coil in the post, and produces a deflection on the galvanometer and rings the alarm bell at the receiving station. The amount of deflection depends upon the resistance offered by the coil in the particular post. This deflection is noted, and by moving the switch "C" to the right, the line wire is entirely disconnected, the galvanometer needle returns to zero, and as the switch is brought in contact with the coils 1, 2, 3, &c., a current passes from the same battery through the galvanometer and coils locally, as shown by the red line marked local circuit on the diagram. The switch is turned round the dial until the deflection on the galvanometer is reproduced, and thus indicates the exact locality of the post from which the alarm is given. In practice, however, the deflection on the galvanometer is a sufficient indication to the fireman without testing, as not more than four or five posts are on any one line. Three or four fire-alarm lines pass into each fire station. These are separately indicated by a simple arrangement consisting of electromagnets and armatures, by means of which red discs on a small indicator are brought into view. In case a call be given on two or more lines simultaneously, switches are provided by which each line can be dealt with separately. The posts on each line are so arranged that the engine on leaving the station would pass them in regular order; therefore, if the alarm was given from the nearest or any intermediate post, it would be ascertained, without loss of time, as the engine passed.

BATTERIES.

The batteries used are somewhat similar to the Leclanché battery, but larger, and the carbon mixture is placed on the outside of the porous pot with the zinc cylinder inside. The liquid used is a solution of sal-ammoniac. Four cells are generally used for ringing the bells and two for working the telephone instruments. These cells are sufficient to work the fire-alarm switch-boards also. For these batteries Messrs. Blenheim & Co., the manufacturers, claim that they have a less internal resistance and continue in action for a greater length of time, also that they recover in shorter time than the Leclanché battery.

The instrument on the right is Messrs. Blenheim's telephone, which is now being fitted up at the Hornsey Isolation Hospital and Sewage Works. My thanks are due to Messrs. Blenheim, who have kindly lent a set of instruments and have fitted them in this room for the information of the members.

DISCUSSION.

Mr. Silcock: There is just one thing I should like to know, and that is the number of these signalling stations in proportion to the population. It is not very long since there was a paper read in this room, on "The present state of Fire Telegraphs," before the Society of Telegraph Engineers and Electricians, in which there were a great many statistics given as to the proportion of call points in American and in English towns to the population. It would be some guide if we had definite information as to the number of such points that ought to be put down. I have not that paper here, but, so far as I can remember, the proportion in England was very much less than there are both on the Continent and in America. I remember that in London, which is the best provided with such call points of any English town, there is the proportion of something like one call point to every 5000 or 6000 persons. I think Leeds, which is very well provided, has about one to every 8000 or 9000 persons, whereas on the Continent there is one call point for about every 1000 of population, and in America there are a great many more still. Captain Shaw, of the London Fire Brigade, was present when the paper to which I have referred was read, and I remember he made two remarks very much to the point on this subject. One of them was that we should aim at doing away as much as possible with bells and introduce speaking instruments instead. In large towns the fire brigades have a great amount of work to do, and it is very annoying and harassing for the men, who may perhaps turn out with every possible appliance to attend in some street in response to a call by a ring of the bell, and find when they get there that it is merely a chimney fire. If forty or fifty men turn out with a steamer to put out a chimney on fire it harasses the fire brigade very much, and on that ground Captain Shaw advocated that telephones should be introduced as much as possible, instead of merely ringing arrangements. The other suggestion was that to prevent false alarms being given the street call points should be so arranged that when used they should make such a noise that no one within a radius of one hundred yards could fail to be aware of the fact.

Mr. W. N. BLAIR: I just wish to say that at Bootle we have introduced arrangements similar to those described by Mr. Meade at Hornsey. We differ, however, in this respect, that with us the opening of the door rings the alarm; we have not to press or touch any knob in order to do that. We have nine or ten of these stations established at present, by way of experiment. They have acted very well, and so far we have had no false alarms. As regards indicating the situation of the fire, they have established a system, by which the engine at the central station can go direct to the point from which the alarm comes. The first turn out carries everything necessary to deal with the fire working from the mains. If the men find a serious fire, they at once ring the alarm through the street station signal for one engine, or two engines, as the case may be. I believe our superintendent, Mr. Parker, has recently patented this arrangement. Another part of our arrangement is this, that any householder may obtain a numbered key, but if he uses it, he cannot withdraw it from the lock until some one with the engines comes up with a master key and releases it.

Mr. DE COURCEY MEADE: With regard to Mr. Silcock's remark respecting the number of stations, there are fourteen telephones, and twenty-three posts, and this works out to about one post to every 2500 of the present population, exclusive of the telephones. There is a central fire station, and two street stations, and the alarm can be given to them as well as direct to the central station by telephone. In addition to that there is a telephone in the northern part and also in the extreme south-east. I find that the keys described by Mr. Blair are very similar to our own. The keys have each a distinctive number, by which they can be identified, and any attempt to file away the number would render the key useless. Any one using the key cannot release it from the post, and thus, in the event of a false alarm, we could detect the person through the number of the key used. I do not know whether this will prove a better system than the glass in the suburbs of London, but we shall stick to the glass panels until we find false alarms given.

NOTES ON SEWAGE PURIFICATION BY ELECTROLYSIS.

By WILLIAM WEBSTER, F.C.S.

The question of the disposal of sewage has occupied the attention of engineers and chemists for many generations past, and regarded from a hygienic point of view cannot be too thoroughly considered.

Before entering into the particular subject upon which I have the honour of being invited to address you, I should like to turn your attention to the various processes tried, and found wanting, since the year 1762.

We have lately heard a great deal about the treatment of sewage with sulphate of iron, lime, sulphate of alumina, permanganates, &c., &c.; it is a most remarkable fact that claims have lately been made *in re* the sulphate of iron process as if it were entirely new; the following list will show the fallacy of this:—

Names of Substances.	Inventor.	Date.
Sulphate of iron	Deboissieu	1762
Chlorine	Hallé	1785
Lime	Estienne	1802
Powdered charcoal	Giraud	1805
Chlorine and chloride of lime	Guyton Morveau	1805
Ashes	Chaumette	1815
Sand	Duprat	1818
Sulphate of iron	Briant	1824
Chloride of soda	Labarraque	1824
Waste chloride of manganese	Payen and Chevalier	1825
Sulphate of lime	Siret	1827
Animal charcoal	Frigerio	1829
Peat	Guibourt & Sanson	1833
Charcoal and calcined marl or river mud	Pottevin	1836
Sulphates of iron and zinc with tan and tar	Siret	1837
Earth, lime and waste substances	Rossier	1837
Peat ashes	D'Arcet	1840
Metallic oxides and carbon	Krafft and Suequet	1840
Chloride of zinc	Sir Wm. Burnett	1840
Schist coke	Hompesch	1841
Trade refuse, charcoal, and ashes	Albert	1842
Powdered lignite	Jourdan	1843
Impure alum	Siret	1843
Sulphate of zinc, charcoal, and clay	Gagnage and Regnault.	1844

Names of Substances.	Inventor.	Date.
Persulphate of iron	Baronnet..	1845
Schist coke	Du Boisson	1845
Chlorides of iron and zinc	Dubois	1846
Lime and precipitating tanks	Higgs	1846
Nitrate of lead	Ledoyen	1847
Waste salts of iron, lead, zinc, &c., with pyrolig matters, ashes, &c.	Brown	1847
Pyrolignate and perchloride of iron	Ellerman	1847
Impure chloride of manganese	Young	1847
Dried sea-weed, lime, amd sulphate of lime and zinc.	Salman	1848
Peat charcoal	Rogers	1848
Charcoal, soot, mineral salts, &c.	Legras	1849
Spent tan, carbonised..	Tarling	1850
Fresh bark, sulphate of iron, and peat charcoal ..	Angely	1850
Metallic sub-salts, as of iron alumina, &c.	Browne	1150
Milk of lime and collecting the deposit	Wicksteed	1851
Acids and metalic salts, and filtrations through charcoal, clay, peat, gypsum, &c.	Dover	1851
Lime, sulphates of alumina, and zinc and charcoal.	Stothert	1852
Lime, magnesian earth, sulphate of zinc or iron and vegetable charcoal	Gilbee	1852
Sifted ashes, breese, or peat charcoal	Perks	1852
Sulphate of zinc, potash, alum and sand with waste tan, ashes, lime, soot, &c.	Pinel	1853
Metallic sulphates, metalic chlorides, or charcoal and magnesian salts	Herapath	1853
Salts produced in working galvanic batteries ..	Dering	1853
Peat or bog earth containing salts or oxides of iron	Dimsdale	1853
Peat and other charcoal and chloride of sodium, &c.	Macpherson	1853
Animal charcoal, alum, carbonate of soda and gypsum.	Manning..	1853
Magnesia and lime with sulphurous and carbolic acids.	Smith and McDougall.	1854
Lime and finely-divided charcoal	Wicksteed	1854
Boghead coke	Herapath	1854
Soft sludge from alum works with lime and charcoal.	Manning..	1854
Peat charcoal carbonised with oil of vitriol	Longmaid	1855
Alum schist or shale, and other aluminous minerals, with lime and charcoal.	Manning..	1855
Manganates and permanganates	Condy	1857
Superphosphate of lime with magnesia and lime ..	Blyth	1858

To this list may be added others containing combinations of the above, ringing the changes upon iron, lime, alumina, &c., which illustrate the reckless way in which inventors endeavour to apply their knowledge without first ascertaining what has been previously done in the matter, and how far it has been found to be successful.

In the year 1844, lime, mixed with water, was used for the precipitation of sewage, the sewage precipitate was called sewage guano, and, to cut a long story short, it was found that the product had little or no agricultural value. The late Dr. Letheby (whose pupil I was) in the year 1857 recommended the Metropolitan Board of Works to adopt the lime process to precipitate the sewage of London. He also suggested that sulphate of iron might be tried. In this short paper it is not my intention to criticise the many processes in use at the present time, as there is no doubt all are doing their best to solve the question; but I must protest against sewage farms, where sewage is allowed to percolate through the land without previous treatment. Rye grass is grown and ultimately eaten by cattle, sewage contains myriads of ova, they become attached to the grass and other green fodder, this affects the cattle, produces measly meat, and I need hardly enlarge upon the results of eating it.

It may perhaps seem curious that I should say so much about chemical treatment, when the special subject of my paper is electrolytical; but electrolysis is nothing more than a chemical action produced by an electric current.

It is quite ten years since I carried out my first experiments in electrolysis, but in those days the available electric apparatus had not attained such completeness as we now have it. I first of all wish to remove an impression which, I have been given to understand, is lurking in some minds—that it is impossible to electrically decompose pure water. Water is easily decomposed provided the current of electricity is of such intensity that it can overcome the resistance. Nicholson Carlisle decomposed water in the year 1800; the decomposing effects produced are precisely in accordance with the chemical equivalents of the substances electrolysed; for instance—the same amount of electricity that would reduce fifty-six parts of iron from its solution would reduce 207 parts of lead, or sixteen parts of oxygen, &c., &c. This is practically the explanation of the whole system; for the chemical changes which take place in sewage when it is electrolysed, depend chiefly on the well-known facts that water and sodium, magnesium and other chlorides (which are always present in sewage) are split up into their constituent parts. Thus, we have at the positive pole chlorine and oxygen set free, and these elements are liberated in a nascent state, a condition in which they are intensely active, so that the organic matter in the sewage is rapidly oxidised and burnt up to innocuous compounds. So rapid is this action that I will now act on a little Crossness sewage, and produce a disinfecting liquid, which is nothing more or less than hypochlorous acid, the strongest oxidising agent that is known. To obtain this quickly I must separate the positive action from the negative by a porous diaphragm. At the negative pole I obtain ammonia, potass, soda, magnesia, &c. So strong is the action of oxide of chlorine that I have found no pressed carbon plates would stand its action, I am therefore compelled to use cut carbon or coke.

It was this fact that made me investigate the cost, and the result was, knowing that iron salts were of great use in precipitating organic matter in solution, that I experimented with iron electrodes, for the oxidising acids produced by this action being probably 100 times more active than any acids produced by chemical processes alone, it necessarily followed that the iron salt produced must have similar properties. The nascent chlorine and oxygen generated partly unite, and, with the water, form hypochlorous acid; the positive iron plate being attacked, and ferrous hypochlorite formed; but a portion of the hypochlorous acid attacks the organic matter, for it is well known that putrefying sewage has a strong affinity for oxygen.

To still further strengthen this action, I have lumps of carbon cast into the iron plates, thus securing a supply of the before-mentioned acid.

The iron plates are common casts run direct from the furnace into this form instead of pigs, and are used for the positive poles, the negative plates being thin rolled sheet. The positive plates are gradually acted on by the acids produced, but the negative plates are not acted, on, and will remain in the same condition for years; this is so well known that I need not enlarge upon it. I have estimated that the waste of iron at the positive pole is about one grain per gallon, but of course this entirely depends upon the electric current used. The hypochlorite of iron formed at the positive pole is acted on by the free ammonia, sodium, potassium, and magnesium hydrates and the ferrous hydrated oxide precipitated. This particular oxide of iron has the property of combining with organic matter, and it is a peculiarity of this salt to take a white hue, and then by exposure to the atmosphere to become green, and ultimately an ochrey red colour.

This action can be seen almost daily in any dye-house during the dyeing of buffs; the cotton goods (representing organic matter) are dipped into an iron solution, and then passed through an alkaline bath; the shade is green, but slight exposure to the air produces the buff colour; the oxide of iron being precipitated within the fibres of the cotton. The ferrous hydrate or protoxide of iron is so beautifully precipitated, one may say, in its most active condition by this electrolytic process, that it takes up more organic matter than if precipitated chemically, for by chemical precipitation the iron oxide carries a large part of the suspended matter in the sewage with it; but only traces of the dissolved organic matter. In the electrical process the whole of the matter suspended is carried with the oxide of iron, together with a considerable portion of the organic matter in solution, and if necessary, the whole of the soluble organic matter can be oxidised. The precipitate itself is carried to the surface by the numerous bubbles of hydrogen issuing from the negative pole, and the effluent may be run off quite clear from below, or may be run with the precipitate into settling tanks, where the deposit will take place in from half an hour to two hours; the precipitate being exceedingly flocculent subsides readily. The sludge formed does not hold so much water as by chemical process, and presses without any addition of lime. The effluent is less alkaline than the natural sewage, and if necessary can be rendered neutral by passing through coke filters arranged in such a way that the electric current can be applied, thus further purifying the effluent and delivering it in such a state that, personally, I should have no objection in drinking it. The reason of the alkalinity being reduced is that a small quantity of free ammonia is carried off with the hydrogen gas at the negative pole, and also by the formation of hypochlorous acid. It is by means of this coke filter that potable water can be purified either on a large or small scale, and the treated sewage is not liable to secondary fermentation, nor does it form a precipitate when mixed with ordinary river water. The chlorides are slightly diminished in quantity owing to the escape of nascent chlorine at the positive pole. The amount of soluble mineral matter is not increased in quantity as in ordinary precipitating processes.

The chloride of line of commerce is really hypochlorite of lime. It has been suggested that the hypochlorous acid may possibly be as objectionable in its after effects as the salts of lime, but this is not the case, as hypochlorous acid is an unstable compound, which, having delivered up its oxygen in oxidising organic matter, changes into hydrochloric acid, which neutralises the alkalinity of the sewage.

As I have already demonstrated that hypochlorous acid can be obtained in quantities by means of a porous cell enclosing positive pole, so likewise by enclosing the negative pole, a solution of ammonia, &c., can be obtained from the raw sewage.

I have brought with me a weak solution of the disinfecting fluid obtained from sewage twelve months ago; also a sample of an effluent eight months old. I have shown that the sewage can be purified to any extent, even to conversion into a disinfectant; it therefore only remains for me to enter into the question of cost, which I will do as briefly as possible, and it is just as well to mention that this will be partly ruled by the particular state of purity you require in the effluent.

The chief expense is the engine power. My experience up to the present time is limited to treatment of about 100 gallons of sewage at any one time; and from a large number of experiments I found it would be possible to treat this quantity with about one-third horse-power; the dynamo and engine were unsuitable for my experiments, as the dynamo was only fit for electric lighting, and the engine twenty-five years old—without a governor; I should therefore prefer to think the horse-power over-estimated. The time occupied in treating every 100 gallons varied from five to ten minutes. The consumption of iron was one grain per gallon; the cost of this is easily estimated when one knows the market price of pig-iron. By kind permission of the Metropolitan Board of Works, I have erected works at my own expense at the Crossness Outfall of sufficient capacity to treat sewage at the rate of one million gallons per diem; as I have sufficient confidence in this process to risk the large outlay entailed. For this I have had an Edison-Hopkinson dynamo specially constructed giving an output of 1600 ampères and twenty volts.

Unfortunately the electrical portion of the works is not yet completed, or I should have hoped to have had the pleasure of inviting you to inspect them.

The question of cost resolves itself into this: The more iron plates you introduce into the system, the greater the surface, and the lower the resistance, consequently the less horse-power required. The increase of the iron plates is only an increase of prime cost, and does not mean a greater waste of iron; this means a saving of labour, as the more iron originally used the less frequently it would require renewal.

I hope to prove that by using positive plates one inch thick their duration will be from five to ten years. If the proportion of one-third horse-power to 100 gallons in ten minutes holds good, as I am inclined to think it will, then twenty-five actual horse-power would be capable of purifying 1,080,000 gallons of sewage in twenty-four hours. I should much have liked to have gone into more minute details connected with these experimental tests, but until I have verified the present results on a practical working scale I feel it would be premature to quote figures.

Appended are the results of a few Analyses of Sewage before and after treatment:—

PARTS PER 100,000.

Date of Experiment.	Appearance.	Odour.	Nitrogen as			Chlorine as Chlorides.	Oxygen required to oxydise organic matter.	Total Solid Matter in Solution.	Loss on Incineration of total Solids.	Suspended Matters.			
			Free Ammonia.	Albumenoid matter.	Nitrites and Nitrates.					Total.	Mineral.	Organic.	Ferric Oxide. Fe_2O_3
1888. a. Mar. 26	Raw Sewage, very turbid and opalescent	Bad	2·59	0·47	None	9·74	1·95	61·72	12·57	65·28	39·47	25·79	7·09
	Effluent, clear ..	None	2·30	0·30	None	9·19	1·07	57·43	9·14	None	..	..	..
b. Apr. 20	Raw Sewage, very turbid and opalescent	Slight	1·88	0·19	Trace	5·27	1·17	42·43	7·90	47·31	33·01	14·30	6·13
	Effluent, clear ..	None	1·63	0·14	0·029	4·67	0·53	38·60	4·10	2·01	1·74	0·27	1·69
a. Apr. 27	Raw Sewage, very turbid and opalescent	Slight	2·65	0·42	None	16·43	1·24	41·95	5·86	Not estimated.			
	Effluent, clear ..	None	2·28	0·18	0·017	13·79	0·52	37·40	2·85	None	..	..	..

a. a. Time allowed for settling, two hours.
b. „ „ „ „ half an hour.

CANAL WATER CONTAMINATED WITH SEWAGE.—LABORATORY EXPERIMENTS.

CARBON PLATES.

AVERAGE OF 40 ANALYSES.

	Per gallon. Free Ammonia.		Per gallon. Albumenoid Ammonia.
Before treatment	·073	..	·037
After treatment	·053	..	·014

IRON AND CARBON PLATES.

AVERAGE RESULT OF 5 ANALYSES OF SEWAGE.

			Per gallon.
Before treatment	—	..	·431
After treatment	—	..	·08

DISCUSSION.

Mr. **Midwinter**, F.I.C.: I have had opportunities of seeing a good deal of Mr. Webster's process, and it appears to me that in it we are able to combine the results obtained by both precipitation and irrigation in the same tank. This is equivalent to saving an enormous expense in the shape of land, chemicals, and working expenses. You will see by the analyses that the organic matter is reduced about one hundred per cent. and the nitrogenous organic matter, that is nitrogen as organic matter, is reduced about one-third. Having had some experience in analyses of sewage effluents, I know of no other process which gives equally good results.

The **President**: I have no remarks to make upon the paper, but our thanks are due to the author for having taken a very unusual course with gentlemen who have devoted themselves to scientific investigations, by putting us in possession of certain data in the middle of those experiments. Mr. Webster has done precisely what I suggested in my address should be done on a larger scale, viz. made an original scientific research on the sewage question and communicated the result before the final experiments are concluded, thus putting us in possession of the exact position which the investigation has reached, and we are exceedingly indebted to him for the trouble he has taken, and for the interesting information he has given to this Association.

Mr. S. C. **Trapp**: I consider this one of the most practical and valuable papers that has been brought before us. The only thing of all others that sanitary engineers are trying to find out is the best method of treating sewage. If Mr. Webster's plan proves successful, I think it seems the most sensible plan yet put before us, and we are much obliged to him for the information he has afforded.

Mr. **Gordon**: I should like just to say this, that this Association is very greatly indebted to Mr. Webster for selecting this as the first Association to which he has thought it right to publish his views on this important question, as he has kindly done this morning.

On the first day, by permission of H.M. Office of Works, a visit was paid to the new drainage works constructed on the

Shone system at the Houses of Parliament. In the evening the members dined together at the Criterion Restaurant, Piccadilly, and amongst the visitors were Sir Robert Rawlinson, K.C.B., Dr. Richardson, Major Tulloch, &c.

On the second day visits were paid to Messrs. Jennings' works, Stangate Wharf, Lambeth; and to the Lucigen Light Works, Brin's Oxygen Works, and the New Battersea Bridge in course of construction.

On the third day the members proceeded by steamer down the River Thames to the Greenwich Ferry Works, after which they visited the new Outfall Works at Barking designed for the treatment of Metropolitan Sewage. Here one of the sludge ships, 'The Bazalgette,' was moored for the inspection of members.

APPENDIX.

VOLUNTARY EXAMINATIONS.

SYLLABUS.

The Association of Municipal and Sanitary Engineers and Surveyors have undertaken the holding of Voluntary Pass Examinations for Candidates for Surveyorships under Municipal Corporations and the Local Government Acts.

There will be two Examinations in each year, one in April, in London, and one in October.

The Examinations will be by written papers and *viva voce*, upon the four following subjects:—

1st. Engineering as applied to Municipal work.
2nd. Building Construction and Materials.
3rd. Sanitary Science as applied to Towns and Buildings.
4th. Public Health Acts, and Rivers Pollution Acts.

Examples of the class of questions proposed to be asked under these heads are appended hereto.

Candidates will be allowed two hours to answer the questions under each of the four heads, and will not necessarily be required to answer all the questions set in each paper, though not less than four must be taken: marks will be given for all questions properly answered. The *viva voce* examination will be held after the written papers have all been sent in, and will be directed to the further elucidation of the answers to the papers on each subject, and to such practical points as fairly arise therefrom.

The Examinations will extend over one or two days, as circumstances may require, and in the latter case the arrangements will be, as far as possible, as follows:—

First day ..	10	to	12 ..	Engineering.
„ ..	2	„	4 ..	Building Construction.
„ ..	5	„	7 ..	Sanitary Science.
Second day ..	9.30	„	11.30	Public Health Law.
„ ..	1	„	4 ..	*Viva voce* Examination.

The total number of marks required to constitute a pass will be 50 per cent. in each of the subjects.

Each candidate has to fill a Form of Application, to be obtained from the Secretary.

The fee for each Examination will be 3*l.* 3*s.*, one guinea to be paid on application, and the balance on the day of examination. Should the candidate fail, he will be entitled to present himself again at the next, or any subsequent Examination, on payment of one-half of the above fee.

No further charge will be made to the candidate than the fees above mentioned.

Candidates that do not present themselves for the Examination forfeit the entrance fee.

Successful candidates will be entitled to receive a Certificate in the form of a "Testamur," signed by the Examiners for the time being, and countersigned by the President and Secretary of the Association in Council.

Further details and particulars may be obtained on application to Mr. Thos. Cole, Secretary to the Association, 6, Westminster Chambers, Victoria Street, S.W.

SUBJECTS OF EXAMINATION.

I.—ENGINEERING AS APPLIED TO MUNICIPAL WORK:

A. Land Surveying and Levelling.
B. Hydraulics.
C. Drainage and Sewerage.
D. Water Supply.
E. Road Making.

II.—BUILDING CONSTRUCTION: STRENGTH OF MATERIALS:

A. Materials.
B. The Construction of Public and Private Buildings.
C. Building Bye-laws.

III.—SANITARY SCIENCE AS APPLIED TO TOWNS AND BUILDINGS:

A. Ventilation.
B. Sewage Disposal.
C. House Drainage.

IV.—PUBLIC HEALTH ACTS.
RIVERS POLLUTION ACTS.

FOURTH EXAMINATION.

The Fourth Examination of candidates was held at the Town Hall, Manchester, on Friday and Saturday, the 7th and 8th of October, 1887, at which the following Examination Papers were set to the candidates.

SUBJECT:—ENGINEERING AS APPLIED TO MUNICIPAL WORK.

E. B. Ellice-Clark, M. Inst. C.E., Examiner.

1. *Instrumental Work.*—Before commencing observations with the theodolite it is necessary to adjust (*a*) the telescope; (*b*) the horizontal limb; (*c*) the vertical limb. The adjustment of the telescope is to make provision for two important errors. What are they?
2. *Surveying.*—Sketch the main lines and ties you would chain in surveying the streets shown on the accompanying plan. If you consider it necessary to use a theodolite, show the manner in which you would enter the angles in your Field-book. How would you indicate the levels of the surface and sewers?
3. *Levelling.*—In giving the levels for the construction of a sewer, describe the method you would adopt to ensure the invert being laid to the correct depths and gradients.
4. *Hydraulics.*—What is meant by the term "Wetted perimeter?" What causes a syphon to work? How many feet in height will an overhead syphon work in practice? What does the height of the barometer indicate in relation to the working of a syphon?
5. *Sewerage.*—Sketch * an open trench, in a wet clay subsoil, for a sewer 4 feet 6 inches by 3 feet—depth 20 feet to bottom of cutting. Show the necessary timbering. Write the distinctive names, and figure the dimensions of each piece of timber used in securing the trench.
6. Sketch * the egg-shaped sewer, 4 feet 6 inches by 3 feet, with diagram showing how the radii of the invert, sides and arch are determined Give the thickness of brickwork necessary under the conditions named in Question 5.
7. Presuming good ballast could be obtained as an aggregate for concrete, show how you would dispose the material in constructing a concrete sewer, giving (*a*) dimensions; (*b*) proportions of cement to aggregate.
8. What are the advantages and disadvantages of using wholly mass concrete for such a sewer in the principal streets of a large town? (*a*) temporary; (*b*) structural.
9. In calculating the capacity of outfall sewers, what rainfall in twenty-four hours would you provide for in the town where you reside? State town?
10. Without a separate system. In making provision for the relief of sewers from storm waters—i. e., heavy falls in short periods—what information is necessary to determine the capacity of the necessary relief works?

* **Sketches need not be made to scale.**

11. How would you gauge the flow of a sewer, if the inclination were not known?
12. *Paving.*—Under what conditions would you consider it necessary to abandon macadam, and pave a street with pitchers?
13. How would you ascertain the annual burden borne by a street, and what unit would you adopt so as to compare your calculations with those of other engineers?
14. *Lighting.*—What is meant by "average meter indication?" Give a description of it, and the appliances used to effect it successfully?

SUBJECT:—BUILDING CONSTRUCTION, &C.

W. Geo. Laws, M. Inst. C.E., Examiner.

1. Name the woods chiefly used in ordinary building, and the qualities and uses of each.
2. Give the composition of good mortar. What are the most common faults of mortar used in "jerry" work, and how are they detected?
3. Describe "Ashlar," "Block in Course," "Snecked Rubble." Specify briefly for a wall built in *one* of these modes.
4. What is "Stoothing?" Describe its construction, and say where it is applicable, and where not.
5. What is the difference between "flat" and "tuck" pointing? Give a sketch of each. What is meant when joints are specified "to be drawn in with a key?"
6. Describe the process of "plastering" inside walls, naming each coat, and its composition.
7. Sketch a "Queen post" roof couple, and name the members. In what cases is it applicable?
8. What are the chief precautions to be taken in arranging the "exits" from a public building (say a theatre) as regards doors, passages, and stairs?
9. Give a sketch section of an ordinary house floor, showing the joists and flooring boards, and the ceiling of the room below, and describe how they are put together. Show how "deafening" is put in.
10. What are the requirements of the Model Bye-laws as to the thickness of house walls? Give these briefly in your own words.

SUBJECT:—SANITARY SCIENCE.

Joseph Gordon, M. Inst. C.E., Examiner.

1. *Ventilation.*—State the general features to be kept in view to secure as perfect a ventilation of town areas as possible:
   - (*a*) Width of streets.
   - (*b*) Length of streets without cross streets.
   - (*c*) Minimum area of open space at rear of each building, and minimum width or depth thereof between outbuildings and fence wall at the rear.
   - (*d*) State what other means of ventilation than by windows and fireplaces are desirable for the interior of dwellings; also for public halls, churches, hospitals, &c.
   - (*e*) Why is it requisite that sewers and house drains should be ventilated, and what are the usual methods resorted to in each case?

2. *Building Site and Sanitary Arrangements.*—What precautions does sanitary science require should be taken to secure a healthy site and conditions for dwellings—

(*a*) Suppose the subsoil to be of a doubtful character, how would you deal with the site to be built upon?

(*b*) What position would you assign to water closets in the interior of dwellings in order to ensure proper light and ventilation and the greatest possible isolation from dwelling and sleeping apartments, and give sketch to illustrate your views as to the position of w.c.'s, sinks, baths, &c.

3. *Sewage Disposal.*—Give description of the chief methods of sewage disposal and treatment, and state—

(*a*) Under what circumstances chemical treatment seems more practicable than an application of the sewage to land, with particulars of some of the chemical methods at present in use.

(*b*) When and under what conditions intermittent filtration is resorted to, with some particulars of this method of sewage disposal, and quantity of land requisite per 1000 inhabitants or per million gallons of sewage.

(*c*) Give some particulars of the application of sewage to land upon the broad irrigation system, and the area of land requisite per 100 inhabitants or per million gallons, according to the nature and quality of the soil and subsoil.

(*d*) Is the difficulty of disposing of the sewage at the outfall of any sewerage system at all lessened or attended with less expenditure where the earth closet or pail system is chiefly in vogue instead of water closets; and, if so, is it at all commensurate with the increased cost of collection of the earth closets or pails in large towns?

4. *Sewering of Towns.*—In sewering a town how would you proceed to determine the maximum dry weather volume of sewage during the day to be carried off through the sewers, and what provision beyond this would you make for rainfalls per hour in determining the sizes of your sewers?

5. What minimum velocity is requisite for sewers to be reasonably self-cleansing, and how would you obtain this in localities where the natural levels of the district do not admit of gradients producing such a velocity?

6. Why are so-called dead ends objectionable in sewerage systems, and how would you avoid them? Illustrate a case in point, and show what alterations and additions to a system of sewers are requisite to dispense with them.

7. Under what conditions would the separate system—that is, one set of sewers for rain water and another for sewage—be advantageous?

8. *Water Supply.*—What are the usual precautions taken to prevent the possibility of the water supply for culinary, drinking, and other domestic purposes, becoming contaminated from w.c.'s, &c., within a house?

9. *House Drainage.*—Describe the chief features to be kept in view in designing house drainage under the following headings:

   (*a*) How baths should be dealt with, and under what conditions you would consider it essential to ventilate a bath waste-pipe.

   (*b*) How would you deal with the soil-pipe of a water closet, and of what materials would you construct it; in what manner would you ventilate it, and under what conditions would you consider it essential to disconnect it or other parts of the house drainage from the public sewers?

   (*c*) Where disconnection is considered essential, in what positions would you place the disconnecting syphons, and what gradient would you consider essential on the house side of the syphon to keep it clean; and under what conditions would you consider such a syphon inadmissible?

   (*d*) Where it is impracticable to drain a house without passing the drain through it, what materials would you use, and what other precautions would you take, to secure healthy conditions? Illustrate your views by a sketch section through house, showing drain and precautions referred to.

SUBJECT:—PUBLIC HEALTH ACTS AND RIVERS POLLUTION ACTS.

H. P. Boulnois, M. Inst. C.E., Examiner.

1. Mention the Acts which empower persons to break up the public streets for different purposes.
2. Under what powers can an Urban Sanitary Authority execute the following works?—
   (*a*) Fix a bracket lamp against a wall of private property.
   (*b*) Fix a street "name plate" against a wall of private property.
   (*c*) Erect a urinal in a street, "not repairable by the inhabitants at large."
3. What are the conditions laid down in the Public Health Act, 1875, under which existing cellars may be let or occupied as dwellings?
4. State the surveyor's legal duties when he finds a house within his district to be "without a sufficient water closet, earth closet, or privy."
5. How many Acts and Amendments thereto are there in force with regard to artizans' and labourers' dwellings and lodging-houses?
6. What is the maximum length of drain an owner can be compelled to construct to connect his premises with a public sewer?
7. What restrictions are placed upon the choice and construction of a cemetery under the Cemetery Clauses Act? and give the date of this Act.

Nine candidates presented themselves for examination, of whom the following six satisfied the Examiners, and were granted their certificates of competency:—

J. Cook (Bury).
T. E. W. Mellor (Stockton).
J. W. Metcalf (York).
W. Parker (Hereford).
R. W. Smith-Saville (Accrington).
F. D. Ward (Manchester).

FIFTH EXAMINATION.

The Fifth Examination was held at the Institution of Civil Engineers, Westminster, S.W., on Thursday and Friday, the 27th and 28th April, 1888, when the following Examination Papers were set to the candidates.

SUBJECT:—ENGINEERING AS APPLIED TO MUNICIPAL WORK.

J. Gordon, M. Inst. C.E., Examiner.

1. Give sketch of survey lines for open country district of not less than six fields, with specimen field book for two of the lines, with set-offs, &c.
2. Give sketch of some portion of an imaginary town survey, showing the angles of the main lines as obtained by the Theodolite, and describe the mode of checking the chained lengths of such lines from the angles and base line.
3. Give example of level book, with a line of levels across an imaginary valley, and check levels back to starting point.
4. Give section of a 40-foot street or road, showing:
    (*a*) Mode of construction for a macadam carriage-way and gravel footways, with character of foundation recommended.
    (*b*) Mode of constructing tar macadam carriage-way and tar paved footways.
    (*c*) Paving carriage-way with granite sets or wood blocks, and footways with small granite squares, York flagging, or Victoria stone;

    with short description or specification sufficient to show clearly to a contractor the method of construction intended.
5. Give sketch of a main sewer along a road, with a subsidiary sewer in a street parallel therewith at a higher level, and running in the same direction, but with a distance of 300 yards between the two streets, and with cross streets running between them, sloping towards the main sewer; and show mode of sewering the latter, together with the positions and distances between manholes and lampholes, or other proposed inspection shafts. Assume for the purpose that the main sewer is an egg-shaped brick sewer 3 feet 6 inches by 2 feet 4 inches in size, and the subsidiary sewer 1 foot 6 inches diameter, with sewers 12 inches and 9 inches respectively for the cross streets. Show gullies in streets, and their distances apart, and give sketch of construction of manholes and lampholes, and any proposed flushing arrangements. Also sketch section of proposed construction and material of egg-shaped sewer.
6. Give sketch of bell-mouthed junction of two brick sewers with side entrance and flushing gate in connection therewith.

7. Give sketch of approved method of connecting a ventilating pipe up the side of a house with a street sewer.

8. If called upon to devise a system of sewers for a town of say 60,000 inhabitants, the area of the district under the Local Authority being 900 acres, and 600 acres only built upon, what data as regards volume of sewage and rainfall would you advise being adopted for determining the size of the main sewer under the following conditions, viz.:—That one-third of the present built upon area would form a low-level district, which would have to be pumped a height of 20 feet into the main sewer for the remainder of the district, which would then flow by gravitation to a sewage farm some distance below the town; and that a stream runs through the town the levels of which admit of storm overflows being constructed.

    (*a*) Would you recommend separate storm-water sewers for the higher districts as well as the low level district in such a case?

    (*b*) What provision for rainfall would you make in addition to ordinary sewage for the populated area, and would you in the main outfall sewer, have any regard to the unpopulated area as one eventually to be covered with buildings and drained to the main sewer?

    (*c*) What volume of sewage would you provide for?

    (*d*) Having determined the quantity or volume of sewage and rainfall to be provided for as above, state how you would proceed to determine the size of the main sewer with a gradient of 1 in 1000 necessary to carry off such volume when running full.

9. (*a*) What size of rising main would be required for a pumping scheme of water supply for a town of 50,000 inhabitants, the consumption being taken at 20 gallons per head per day, the flow per hour to be taken as one-twelfth of the day's supply, and the velocity in the pipe not to exceed 3 feet per second?

    (*b*) What would be the nominal H.P. necessary to raise the full day's supply to the service reservoir in twelve hours, the height of the reservoir above the pump well being 100 feet, and the friction due to the length of the pipe 10 feet?

SUBJECT:—BUILDING CONSTRUCTION, &C.

W. Geo. Laws, M. Inst. C.E., Examiner.

1. Describe the manufacture of ordinary "Stock" bricks. Why are hand-made bricks superior in lasting quality to machine-made?

2. In what do "Portland" and "Roman" Cement differ? In what case would you use the latter?

3. What is "Ashlar?" Explain the meaning of the terms "Draft," "Chamfer," "Boasting," and "Tooling," in stone dressing.
4. What do you understand when a building is described as of "brick with stone dressings?" Specify shortly for the *external* walls of a good Terrace House so built.
5. In a slated roof what "lap" would you specify say with "Countess" slates? What are flashings, and how and where applied? What is sarking?
6. Sketch the arrangement of the floor joists in a dwelling room 18 feet by 14 feet (with fireplace in long side), and give the sizes and spacing you would adopt. What weight per square foot would just break down your floor?
7. Sketch a flight of stairs with landing, and show how it is put together. What is the best proportion of "tread" to riser?
8. If called on to inspect a new house ready for letting, how and where would you look for evidences of its being "Jerry" built or otherwise?
9. Describe how the walls of a "Concrete" house are run up. What advantage has this mode of building, and what are its faults?
10. What constructive precautions (if any) are prescribed in the Model Bye-laws with relation to fire? Give them in your own words.

SUBJECT:—SANITARY SCIENCE.

H. Percy Boulnois, M. Inst. C.E., Examiner.

1. Give the number of cubic feet contained in the above building, the ceiling being 15 feet 4 inches above the floor level.
2. *Ventilation.*—If you had to adopt it as a small-pox hospital, state the number of patients it would hold, having regard to the cubical space allowed for each patient.
3. Describe, by sketch or otherwise, the special means of ventilation and heating you would suggest for this building.
4. *Sewage Disposal.*—Describe the meaning of the following terms—
   (*a*) Rough precipitation and subsequent irrigation.
   (*b*) Deposition of solids and subsequent filtration.
   (*c*) Oxidising effluent by cascading.
   (*d*) Coagulum in sewage, produced by chemical re-agent.
5. State briefly the difference between the Liernur and Shone systems of sewerage.
6. Give the component parts of "Sludge," and describe some process of dealing with it.
7. Sketch a section of a two-storied, six-roomed dwelling house (without any open area at the side), showing the sewer in the street, and the details of the drain and soil pipes, the W.C., sink, bath, R.W.P., and Cistern wastes, &c.

8. *House Drainage.*—Give replies to the following questions:
    - (*a*) The least allowable number of gallons of water for the flush of a "wash out" W.C. pan.
    - (*b*) The internal diameter of the flush pipe.
    - (*c*) The depth of seal of a six-inch syphon.
    - (*d*) The least allowable fall for a house drain.
    - (*e*) The precautions necessary where a drain passes under wall of house.

SUBJECT:—PUBLIC HEALTH ACTS AND RIVERS POLLUTION ACTS.

E. B. Ellice-Clark, M. Inst. C.E., Examiner.

Public Health Act.

1. What are the powers of an URBAN SANITARY AUTHORITY as to the LIGHTING OF STREETS?
2. Can a RURAL SANITARY AUTHORITY LIGHT STREETS, and if so, what action has the authority to take to carry out their intention?
3. On whom is cast the duty of Supplying, Fixing, and Maintaining FIRE PLUGS?
4. What are the duties of the SURVEYOR under SECTION 62, by which LOCAL AUTHORITIES may require HOUSES to be SUPPLIED WITH WATER under certain cases?
5. For what purposes may an URBAN SANITARY AUTHORITY combine with a RURAL SANITARY AUTHORITY so as to form an UNITED DISTRICT?
6. If it is necessary to WIDEN A STREET, what steps must a SANITARY AUTHORITY take to effect such a Scheme?
7. What powers are invested in LOCAL AUTHORITIES to ENTER LAND for the purposes of the Act?
8. What restrictions are placed upon the CONSTRUCTION of WATER-WORKS by a Sanitary Authority?
9. By Section 331 certain persons are AUTHORISED to DIVERT and ALTER Public Sewers:—
    - (*a*) Name the persons so authorised.
    - (*b*) What conditions must be observed by persons making such alterations?
    - (*c*) What are the duties of the Surveyor under this Section?

Rivers Pollution Act.

1. Can MANUFACTURERS compel Sanitary Authorities to give FACILITIES for the DISCHARGE of LIQUIDS PROCEEDING FROM THEIR FACTORIES?

2. Under what conditions can a Sanitary Authority REFUSE TO PERMIT THE DISCHARGE of the LIQUIDS of MANUFACTURERS into the Public Sewers?

   (*a*) As to the Sewers.
   (*b*) As to the Sewage Disposal.
   (*c*) As to the Sewage Matter.
   (*d*) As to the Volume of Sewage.
   (*e*) As to any Legal Liabilities.

Twenty-three candidates presented themselves for examination, of whom the following fourteen satisfied the Examiners, and were granted their certificates of competency:—

S. W. J. Barnes (Ealing, W.).
G. H. Bayley (Salford).
J. C. S. Beynon (Exeter).
J. G. Bryans (Sunderland).
C. H. Cooper (Wimbledon).
A. Crow (Stratford).
A. R. Finch (Finchley).
S. N. Glass (Hackney).
R. M. Gloyne (Manchester).
J. Houghton (King's Heath).
G. T. Lynam (Barnsley).
G. P. Milnes (Wakefield).
T. Pritchard (Richmond).
C. L. W. Wilson (Bacup).

BOARD OF EXAMINERS.

Lewis Angell, M. Inst. C.E., F.R.I.B.A., Borough Engineer, West Ham (Past President).

H. P. **Boulnois**, M. Inst. C.E., Borough Engineer, Portsmouth (Vice-President).

C. **Dunscombe**, M.A., M. Inst. C.E., City Engineer, Liverpool (Member of Council).

E. B. **Ellice-Clark**, M. Inst. C.E., County Surveyor, West Sussex (President).

Joseph Gordon, M. Inst. C.E., Borough Engineer, Leicester (Past President).

C. **Jones**, Assoc. M. Inst. C.E., Surveyor to the Local Board, Ealing, W. (Past President).

W. G. **Laws**, M. Inst. C.E., City Engineer, Newcastle-on-Tyne (Past President).

Jas. Lemon, M. Inst. C.E., F.R.I.B.A., Consulting Engineer, Southampton (Past President).

Jos. Lobley, M. Inst. C.E., Borough Engineer, Hanley (Past President).

E. **Pritchard**, M. Inst. C.E., 37, Waterloo Street, Birmingham (Past President).

R. **Vawser**, M. Inst. C.E., Manchester (Past President).

W. H. **White**, M. Inst. C.E., Engineer to the Local Board, Oxford (Past President).

CANDIDATES WHO HAVE PASSED THE EXAMINATION.

Date of Certificate.		
May 7, 1887	..	Adcock, C. (Liverpool).
May 1, 1886	..	Angell, J. A. (Leytonstone).
May 1, 1886	..	Ashmead, H. (Clifton).
Oct. 16, 1886	..	Ball, G. (Scarborough).
May 12, 1888	..	Barnes, S. W. J. (Ealing).
May 12, 1888	..	Bayley G. H. (Salford).
Oct. 16, 1886	..	Beard, E. T. (Lincoln).
May 12, 1888	..	Beynon, J. C. S. (Exeter).
Oct. 16, 1886	..	Brownridge, C. (Leeds).
May 12, 1888	..	Bryans, J. G. (Sunderland).
May 1, 1886	..	Coales, H. G. (King's Lynn).
Oct. 22, 1887	..	Cook, J. (Bury).
May 12, 1888	..	Cooper, C. H. (Wimbledon).
May 7, 1887	..	Cooper, F. E. (Liverpool).
May 12, 1888	..	Crow, A. (Stratford, E.).
Oct. 16, 1886	..	Crowther, J. A. (Leeds).
May 7, 1887	..	Dearden, Hy. (Leeds).
May 1, 1886	..	Fenton, W. C. (Sheffield).
May 12, 1888	..	Finch, A. R. (Finchley).
May 7, 1887	..	Franks, T. W. (West Bromwich).
May 12, 1888	..	Glass, S. N. (Hackney).
May 12, 1888	..	Gloyne, R. M. (Manchester).
May 1, 1886	..	Greatorex, A. D. (Toxteth Park).
May 1, 1886	..	Harland, A. (London).
May 12, 1888	..	Houghton, J. (King's Heath).
Oct. 16, 1886	..	Jameson, M. W. (Leeds).
May 12, 1888	..	Lynam, G. T. (Barnsley).
Oct. 16, 1886	..	Mallinson, T. (Selby).
Oct. 22, 1887	..	Mellor, T. E. W. (Stockton).
Oct. 22, 1887	..	Metcalf, J. W. (York).
May 12, 1888	..	Milnes, G. P. (Wakefield).
May 7, 1887	..	Nichols, A. E. (Leeds).

Date of Certificate.	
May 7, 1887	Nickols, F. J. (Leeds).
May 1, 1886	Osborne, F. (Dover).
Oct. 22, 1887	Parker, W. (Hereford).
Oct. 16, 1886	Pickering, J. S. (West Bromwich).
May 12, 1888	Pritchard, T. (Richmond).
May 7, 1887	Rich, E. W. (Hounslow.)
May 1, 1886	Saunders, E. E. (Walthamstow).
May 7, 1887	Saunders, Jas. (Newark).
Oct. 22, 1887	Saville, R. W. S. (Accrington).
Oct. 16, 1886	Silcock, E. J. (Leeds).
Oct. 16, 1886	Sykes, E. (Reddish).
Oct. 16, 1886	Thomas, R. J. (Carnarvon).
Oct. 16, 1886	Turner, V. H. (Leeds).
May 7, 1887	Verschoyle, B. (Liverpool).
Oct. 22, 1888	Ward, F. D. (Manchester).
May 12, 1888	Wilson, C. L. W. (Bacup).
May 1, 1886	Witts, J. W. (Skelton).
Oct. 16, 1886	Young, Wm. (Pendleton).

Memoirs of Deceased Members.

The Council, having been requested to append some short notice of the decease of Members of this Association, will feel obliged by early notice being forwarded to the Secretary, with such particulars as it may be desirable to insert in these 'Proceedings.'

A. **Durand Claye**, Ingénieur en chef des Ponts et Chaussées (Assainissement), Paris, an Honorary Member of this Association, and one of the most eminent engineers of the Ponts et Chaussées, died in April 1888.

He was charged with the important service of the sanitary work of Paris, and is the fourth engineer-in-chief whom the municipal administration have lost during the last three years. He was only forty-seven. He had devoted all his professional career, it may almost be said, to the improvement of the sanitary condition of the Seine. It is to him that we owe the utilisation of sewage in agriculture in the peninsula of Gennevilliers. He was, it may be said, universally known and esteemed in the scientific world, and his premature death is a great loss to the city of Paris as well as to the Corps des Ponts et Chaussées.

M. A. Durand Claye was elected an Honorary Member of this Association in May 1887, in consideration of his great public services.

Thomas Coulthurst died in London, June 22nd, 1888. He was born at Preston, Lancashire, where his father practised as an architect fifty years ago. He was trained as a civil engineer, architect, and surveyor, for which profession he early showed great aptitude. His first public appointment was at Gateshead, where he did himself credit in the capacity of assistant borough surveyor. Then he transferred his services to the Lancashire and Yorkshire Railway Company, whom be faithfully served as assistant engineer. But his professional skill and his remarkable activity led him to secure more responsible appointments, and he became assistant architect to the London and South-Western Railway Company, being resident at Southampton and Exeter, after which he secured a similar appointment under the Midland Railway Company at Derby. Having worked with ability and assiduity in the architect's office here, he entered into business on his own account, selecting as the sphere of his operations the then thriving and rapidly growing town of Barrow-in-Furness, in his own county. Mr. Coulthurst also assisted in carrying out extensive works for the late Duke of Portland, at Welbeck. He subsequently entered into partnership with Mr. J. Somes Story, county surveyor, and, during the short existence of the firm of Coulthurst and Story, they designed several of the local Board Schools, and superintended their erection. At the latter end of 1879 the office of borough engineer and surveyor of Derby became vacant, owing to the resignation of Mr. Clement Dunscombe, and Mr. Coulthurst was elected by a large majority. The wisdom of the choice was continually manifested by the ability and rare devotion to duty which Mr. Coulthurst invariably displayed.

In private life, Mr. Coulthurst was kind, courteous, and genial, and he had numerous personal friends to whom his comparatively early decease has been a great loss. He was an Associate Member of the Institute of Civil Engineers and a Member of the Council of this Association.

Samuel Fellows Rowley was born at Sedgley, Staffordshire, and died suddenly of pleurisy on Feb. 6th, 1888, at the early age of twenty-eight. He was articled to the late T. R. Lofthouse, surveyor to the West Bromwich Improvement Commission, and on his death completed his pupilage under the present Borough Engineer, Mr. J. T. Eayrs. He was afterwards appointed assistant, until he obtained the post of Surveyor to the Tipton Local Board of Health in 1883, which appointment he held until his death. His ability, strict integrity, and courteous manners gained the esteem and respect of the whole of the Board and of those with whom he was brought into contact.

The other deaths are Mr. **Thomas Heywood**, Surveyor of Eccles, Barton, Winton, and Monton Local Board, Lancashire; and Mr. **Thomas Cruse**, the Surveyor to the Local Board of Warminster.

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ERRATUM.

In Vol. XIII., 1886–7, page 138, Portsmouth Drainage, the last 9 lines, and the first 3 lines of page 139, remarks by Mr. Angell, were in part incorrectly reported and escaped revision. They should have read as follows:—

"As to the flat sewers, it was desirable to explain the cause. About such flat falls some had great doubts, but the plans were approved by Sir John Hawkshaw, and we had also the authority of Sir Robert Rawlinson for flat sewers. A system of flushing doors was let in at intervals at the manholes, so that the sewers could be regularly flushed, or as often as necessary. When 70 miles of sewerage had to converge to one point, it became a choice of evils: either flat gradients or getting down very low in the earth to pump up again. It was thought that flat sewers, with proper arrangements for flushing, would succeed, but it was recognised as a choice of evils. We all prefer a good gradient when we can get it."